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POLLUTION CONTROL TECHNOLOGY ASSESSMENT

PROCEEDINGS OF AN ENVIRONMENTAL RESOURCES CONFERENCE HELD AT COLUMBUS, OHIO ON MAY 1-3, 1974

NATIONAL ENVIRONMENTAL RESEARCH CENTER

PREPARED FOR
BATTELLE COLUMBUS LABORATORIES

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This volume is a compliation of papers presented at the third of a series of conferences on environmental matters cosponsored by the National Environmental Research Center -- Cincinnati (USEPA) and the Columbus Laboratories of Battelle Memorial Institute, Columbus, Ohio. The conference subject area concerned a multifaceted assessment of water pollution control technology. Session topics included legislative mandates and standards, control technology, activities indirectly affecting water pollution control, an assessment full use of water pollution control technology.

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POLLUTION CONTROL TECHNOLOGY ASSESSMENT

Proceedings of an Environmental Resources Conference

Sponsored by:

U.S. Environmental Protection Agency

and

Columbus Laboratories of Battelle Memorial Institute

May 1-3, 1974
Columbus, Ohio

NATIONAL ENVIRONMENTAL RESEARCH CENTER
Cincinnati, Ohio

October 1974

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U.S. Environmental Protection Agency

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National Environmental Research Center, USEPA

F. M. Middleton
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Battelle-Columbus Laboratories

D. L. Morrison
C. R. Smithson, Jr.

PREFACE

The need for studying the technological, economical, social, and environmental aspects of pollution control is always present. Therefore, this multifaceted assessment of our water pollution control technology is timely.

The Columbus Laboratories of Battelle Memorial Institute and the U.S. Environmental Protection Agency's National Environmental Research Center, Cincinnati, sponsored the conference. Divided into five sessions, the conference focused on the impacts, direct and indirect, on water quality which resulted from various actions taken by Government and industry, in response to environmental control regulations.

We wish to express our gratitude to the many who contributed to the success of the conference.

We acknowledge with appreciation the assistance of Mrs. Lucille G. Pierson of Battelle-Columbus and Mrs. Elaine Cole of NERC-Cincinnati, who gathered and compiled these proceedings.

With the exception of the preliminary pages, NERC-Cincinnati has produced this report as received from Battelle Memorial Institute.

Publication of these papers by the U.S. Environmental Protection Agency does not imply endorsement of either the conclusions or of any commercial product mentioned in these proceedings.

The Chairmen

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INTRODUCTORY REMARKS

F. M. Middleton
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National Environmental Research Center
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

Good Morning, I am Frank Middleton, Deputy Director of the National Environmental Research Center of the USEPA in Cincinnati, Ohio, and co-chairman of this Conference. I would like to add my welcome to that of Dr. Sunderman. Also, I want to thank you for coming to this Conference. This is the third of a series of conferences on environmental matters that have been jointly sponsored by the NERC-Cincinnati and Battelle-Columbus. The 1971 Conference was held on Design of Consumer Containers for Reuse or Disposal, and in 1973, a Conference on the Cycling and Control of Metals was held here at Battelle. Objectives in holding these conferences are to address highly pertinent and timely topics of concern to the Nation. Proceedings of all these Conferences are made available to the scientific and technical community and to leaders in policy-making positions in the country. We will have proceedings from this meeting.

I would like to tell you a little bit about the National Environmental Research Center in Cincinnati so that you will understand our role here and our role in environmental research. Those of us closely associated with environmental research often passively assume that others know a great deal about our organizations and how they work, but many surveys indicate that this is not so. In a recent survey of 3,000 people selected from a cross-section of the American public, only 10 percent of the people were able to name U.S. Environmental Protection Agency unaided. When the Agency's name was mentioned, another 48 percent said yes, they had heard of it; the remaining 42 percent had not heard of the agency. Among even those who were aware of EPA, 40 percent indicated that they knew almost nothing about the agency and only 19 percent said they knew a fair amount about the agency. In August 1971, the Environmental Protection Agency developed the concept of National Environmental Research Centers to integrate the research and monitoring activities of the agency. The centers were established in Cincinnati, Ohio; Research Triangle Park, North Carolina; and Corvallis, Oregon. A year later the fourth National Environmental Research Center was established in Las Vegas, Nevada. These centers were developed along a thematic basis so that each NERC would play a specific role in the mission of the agency. The programs, however, are not limited exclusively to the theme, but the theme serves as the foundation and nucleus for each of the installations. In Cincinnati, the theme is technology development, and it is our activity and interest in this area that led to the development of this seminar. Our programs are heavily oriented toward wastewater and drinking waters, but we also have substantial programs in the area of automobile emissions toxicology, solid and hazardous waste research, methods development and quality assurance, radiological activities, and industrial waste control and oil and hazardous waste spill technology investigated at a satellite laboratory in Edison, New Jersey. Hence, the subject matter of this conference is of significant importance to the activities of EPA at Cincinnati as well as at the other National Environmental Research Centers.

We have gone through, and are still going through, a period of passing far-reaching legislation in the environmental field.

Technology developments for the control of pollution have been proceedings with some vigor. Standards and regulations for our control of pollutants are appearing almost daily, and already, a new National Water Quality Commission is beginning work on the study of the technological, economic, social, and environmental aspects of achieving effluent limitations and goals set forth for 1983 by the Federal Water Pollution Control Act Amendments of 1972. We, therefore, believe that it is quite timely that our water pollution control technology be assessed from a number of viewpoints.

We have assembled an outstanding group of experts to talk, and we want this to also be a discussion meeting. Hopefully, this conference will fulfill these aims. More specific details on the aims and objectives of the Conference will given later this morning.

SESSION I: TECHNOLOGY ASSESSMENT

Moderator:

F. M. Middleton

U.S. Environmental Protection Agency

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TECHNOLOGY ASSESSMENT

(Mid-1974)

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ABSTRACT

This paper does three things. First, it discusses what technology assessment is. This is done in terms of (1) the reasons for technology assessment, (2) the concept, (3) the context, (4) the definition, and (5) the label of technology assessment. Next, (6) the need for something like technology assessment is discussed; this is then followed by (7) an examination of who should do what and why in the technology assessment area, leading up to (8) the establishment of the Office of Technology Assessment in the US Congress.

Second, this paper discusses some of the similarities and differences between technology assessment on the one hand, and environmental impact assessments and statements on the other.

Third, the paper examines the newly created Office of Technology Assessment (OTA) in the US Congress.

INTRODUCTION

I appreciate the opportunity to address this audience on technology assessment. As you were just told, I have been involved in this subject for some time, and talked about it on numerous occasions to various audiences. Hence, when an opportunity such as this one arises, the question that inevitably comes to my mind is this: What can I say that I have not said sometime, somewhere before?

Based on your show of hands, it seems that most of you would welcome a brief synopsis as to where technology assessment came from, and what it is intended to accomplish. For this reason, repetition of parts of some of my previous talks should cause no problem, and therefore I will organize my presentation along the following three lines:

(1) What thechnology assessment is.

(2) How technology assessment differs from environmental impact assessments and statements.

(3) Organization of the Office of Technology Assessment (OTA) in the Congress.

WHAT TECHNOLOGY ASSESSMENT IS

Reason for technology assessment

In recent years we have become increasingly concerned about the deterioration of the quality of human life. Due to unforeseen, deleterious side effects, certain innovations like DDT, which have done a great deal of good in some ways, have endangered or degraded our lives in others. The pollution of our lakes and streams assaults our senses. Rapid population growth and the concentration of poeple in urban regions have created severe disharmonies.

Concept

Since technology plays a highly significant as well as a visible role in the solution of many of our problems, there has arisen a desire to "preplan" the use of technology better. The objective of this preplanning is to minimize the potential deleterious side effects of our actions. This has given rise to the technology assessment concept.

Context

But what we do or do not do is really up to our socio-political system, not to our scientific-technical establishment, however extensively many of our industrial products and government programs may depend on science and technology. Furthermore, science and technology represent only one set of the many "enabling mechanisms" that help us attain our objectives. Others lie in such areas as economics, management, labor, political science, institutional arrangements, etc. It is the integrated use of these enabling mechanisms, under the direction of our socio-political system, that can make the difference between success and failure. It is a mistake to look primarily at technology when something has gone wrong. It is also wrong to search primarily for technological solutions, since the best solutions generally involve a combination of technology and other means, or even a combination of non-technological means without any new technology.

Definition

For this reason, most authorities broaden the concept of technology assessment to include a great deal more than what ordinarily comes to mind when we use the term technology assessment, namely: A systematic planning and forecasting process that delineates options and costs, encompassing economic as well as environmental and social considerations, that are both external and internal to the program or product in question, with technology-related "bad" as well as "good" effects.

Label

Hence the label of "technology assessment" was found to be wanting, since it implies a narrower interpretation than what we mean by the concept today. This has caused considerable confusion. One manifestation of this confusion is a concern by some that we may be talking about technology arrestment, rather than assessment. It is generally felt, however, that it is too late now to change the label without further compounding the confusion. Instead, we decided to give "technology" a much broader interpretation than what Webster has given it.

In short, we view "technology" in "technology assessment" as a variety of "things," whether these are "technical" or not, in the strictest sense of the word.

Why is something like technology assessment needed?

The fundamental concept of technology assessment is not new, not even in its broader interpretation. What is new, however, is that today's problems that need technology assessment have become more numerous, more severe, and more complex. Also public awareness of these problems has become more acute, and insistence that something be done about them has become more vocal.

Scientists and engineers are often surprized when they find that problems of urban blights, social unrest, environmental pollution, inadequate educational opportunities and health care deficiencies do not respond neatly to scientific and technological initiatives. Even the systems approach, which worked so well in the 1950s and 1960s for developing complex missile systems and for putting man on the moon, simply cannot be used here for at least two important reasons:

(1) The objectives are much more diffuse, relating less to economics and "hard" science and engineering.

(2) The disciplines involved are much more heterogeneous, and we have not yet learned how to orchestrate them for coordinated assaults on our problems.

The apparent need for technology assessment as an integral step in the planning, organizing, and implementing of our activities today is an outgrowth of changes that have been taking place over the past several decades, some of which are:

(1)Technology and management techniques are providing more and more leverage, often with more severe consequences, shorter lead-times and greater impacts.

(2) Mistakes made are becoming more costly; there is an increase in the irreversibility of many of our actions.

(3) There is less damping; our environment is becoming less forgiving of abuses.

(4) Our goals are becoming more complex, and call for correspondingly increasingly complex interdisciplinary approaches.

Who should do what and why?

Who should do technology assessment? The answer is simply "everybody" whose contemplated actions may unintentionally but adveresely affect the environment (physical as well as social) in which he operates.

Why? It is a simple matter of striving not to cause indiscriminate damage to the environment in which we live. The government has an obligation to see to it that beneficial programs in one area do not cause more damage in another to the net detriment of the public. It is in the interest of industry not to be viewed by the public, and hence its markets, as the "exploiter"of the public's physical and social environments.

Hence, it is difficult to argue with the concept. It is when we talk about implementations that the issues become controversial.

Now that technology assessment is institutionalized, will it tend to turn to technology arrestment? Definitely not, if we keep two requirements in mind, both of which are consistent with the spirit of the movement or concept.

(1) Technology assessment, as practiced within the Office of Technology Assessment of the US Congress, must not even resemble some regulatory entity. It should be some sort of staff function, to generate unbiased assessments, by laying out options and "costs" for the public to scrutinize and for the government (and especially Congress) to study and act upon. An improvement in the quality of public debate, legislation, and program management, through a better understanding of the many variables at play, will be the true measure of the effectiveness of a technology assessment function, or more specifically of the Office of Technology Assessment (OTA).

(2) Technolgy assessment must not stifle basic research, scientific innovation, or creativity. Rather it should help us gain badly needed insights into our world of ever increasing complexity, so that in turn, our decisions and actions could become more reasoned and hence more rational.

Office of Technology Assessment (OTA)

Public Law 92-484, the Technology Assessment Act of 1972, created near the end of 1972 the Office of Technology Assessment (OTA) within the Congress of the United States.

What is most significant about this development is that perhaps for the first time, our legislative branch, which authorizes and appropriates all federal funds, and which makes the laws that govern us all, can have within its midst a high calibre, sophisticated, analytical capability to help it understand the multitude of issues of ever - increasing complexity, which Congress must resolve and act upon. The potential national marginal utility of OTA is inestimably great!

HOW TECHNOLOGY ASSESSMENT DIFFERS FROM ENVIRONMENTAL IMPACT ASSESSMENTS AND STATEMENTS

To an audience such as this one, with extensive representation from the Environmental Protection Agency (EPA), the question posed by the above sub-heading should be one of considerable interest.

Both, technology assessment, and environmental impact assessments and statements address the deleterious side effects of our actions. But, while EPA's primary concern is with the physical environment, technology assessment concerns itself with a broader spectrum, that also includes among others the social environment. Yet, it is not an easy matter to find topics which can be clearly placed within the purview of EPA or OTA at the exclusion of the other.

Two examples come to mind, which may be appropriate subjects for technology assessment, but not for attention by EPA.

(1) Potential genetic manipulations and their impacts on our general social fabric (present and future), and
(2) Large national data banks (computerized), and their implications for invasion of privacy.

Such examples are difficult to identify, and the the two major differences between EPA and OTA do not derive primarily from differences between their respective substantive jurisdictions. The two major differences derive, instead, from the following situations:

(1) The law which established EPA requires that each Federal entity prepare environmental impact assessments and statements with regard to their contemplated actions, that might affect the environment adversely; and then these statements are to be reviewed and acted upon by others, conceivably interfering with the initially contemplated program.

Technology assessment, as presently institutionalized in OTA, addresses issues on a highly selective as opposed to some all encompassing basis. The primary objective of OTA is to inform the public and aid Congress in its deliberations. It is a "staff function" to be informative...to delineate.. to enlighten...etc., as opposed to anything even resembling some regulatory function, or some other, able to bring about injunctions.

(2) EPA and its functions and responsibilities are within the executive, while those of OTA are within the legislative branch of government.

THE INSTITUTIONALIZATION OF TECHNOLOGY ASSESSMENT IN THE OFFICE OF TECHNOLOGY ASSESSMENT IN THE UNITED STATES CONGRESS

Public Law 92-484 calls for a 13 member Technology Assessment Board, including six Senators and six Congressmen, equally divided among Democrats and Republicans. During an odd-numbered Congress a Senator serves as the chairman, and a Congressman as the vice-chairman. During an even-numbered Congress the roles are reversed.

The make-up of the Board as of this writing is as follows:

Sen. Edward M. Kennedy (D-Mass.) Chairman
Rep. C. A. Mosher (R-Ohio), Vice Chairman
Sen. E. F. Hollings (D-S.C.)
Sen. H. H. Humphrey (D-Minn.)
Sen. C. P. Case (R-N.J.)
Sen. R. S. Schweiker (R - Pa.)
Sen Ted Stevens (R-Alaska)
Rep. J. W. Davis (D-Ga.)
Rep. O. E. Teague (D-Tex.)
Rep. M. K. Udall (D-Ariz.)
Rep. C. S. Gubser (R-Calif.)
Rep. M. L. Esch (R-Mich.)
E. Q. Daddario, Director OTA, (13th member)

In addition there is a twelve-member Technology Assessment Advisory Council, comprized of ten public members, the Comptroller General and the Director of the Congressional Research Service of the Library of Congress.

The make-up of the Advisory Council as of this writing is as follows:

Dr. Harold Brown, Chairman
Dr. Edward Wenk, Jr., Vice Chairman
Mr. J. Fred Bucy
Mrs. Hazel Henderson
Mr. Lester S. Jayson
Mr. J. M. (Levi) Leathers
Dr. John McAlister, Jr.
Dr. Eugene P. Odum
Dr. Frederick C. Robbins
Mr. Elmer B. Staats
Dr. Gilbert F. White
Dr. Jerome B. Wiesner

The Director of OTA is former Congressman E. Q. Daddario. The staffing of the Office is currently under way.

Just exactly how OTA will fare, and how effective it will eventually become, is just too early to tell.

First, OTA will have to get institutionally anchored to the existing system. New organizations are rarely readily accepted by the entrenched ones which they join.

Second, OTA will have to earn the respect of a kaleidoscopic variety of constituents through proving its credibility, by laying out options that are sound, and sets of likely consequences as impartially as the "value-free" nature of such consequences will permit, and by refraining from taking unique stands on issues which should be left to members of Congress, but making it easier for them to do so more rationally. And, finally, by assuring for cause, that it, OTA, will not be likened in any fashion to regulatory agencies.

OTA is indeed faced with some Herculian tasks. Its success to get institutionally rooted, and to build the respect and credibility it needs, will depend in no small measure on the subjects it will be asked to assess initially.

Should OTA confront, too early in the game, highly controversial, emotionally charged topics, where "battle lines" have already been drawn, and powerful people have already taken virtually irrevocable positions, then OTA will get "swamped" and dismissed as an "ineffective instrument."

On the other hand, should OTA get involved at the other end of the spectrum with safe trivia, then it will be viewed as irrelevant, and simply "written off."

Initially OTA will have to address issues in the middle of the spectrum, where the subject is important enough to command attention, but not so important or controversial (due to past history) as to jeopardize the demonstrability of OTA's utility. OTA will need some early "wins." By "wins" I mean public recognition of its utility.

I do not wish to imply that OTA should stay away from highly sensitive issues indefinitely. Quite the contrary! But, first things first. I am talking about getting OTA into a position to be able to address important issues, but without being threatened in the process for the wrong reasons.

Another pitfall that OTA is facing, concerns the balance between in-depth, high quality assessments that take months and years, that OTA is likely to support one way or another, and high quality quick-reaction capabilities to assist Congress quickly, when it needs it. The former type of efforts can be and already are being supported by such organizations as the National Science Foundation (NSF). The latter, quick reaction capability is still to be established. If OTA is to be able to provide this, it will have to heavily draw on the technical and intellectual wherewhital of its very own OTA staff. Also, OTA is anything but immune to the political vageries, over which it has virtually no control.

Hence, whether OTA succeeds or fails, will depend on a number of items.

(1) The appropriate selection of the mix of issues, that OTA can manage to get itself involved in.

(2) Political vagaries over which it has no control.

(3) Last but not least the very staff of OTA. Should they fail to establish within their midst a high calibre, substantive, imaginative, politically astute capability, which does not have to go out on contract to respond to Congressional inquiries, with the "best 'quick' answer under the circumstances," then the effectiveness of OTA as a potential instrument will have been compromized, irrespective of what else will happen on other fronts.

Which way OTA will end up ultimately, is simply too early to tell as of this writing.

REFERENCES AND BIBLIOGRAPHY

This address is based on numerous articles, papers and lectures by the author, appearing in such places as:

(1) Chapter in book: Science and Technology Policies, coedited by the author, and published by Ballinger, Cambridge, Massachusetts, 1973.

(2) International conferences, meetings at: Tokyo, Japan (Japan Industrial Planning Association); Paris, France (Organization for Economic Cooperation and Development); Milan, Italy (NATO); England; Germany, etc.

(3) Testimony before the US Congress.

(4) Lectures at various universities e.g. UCLA, Carnegie Mellon, Rutgers, etc.

(5) Various publications, such as: Harvard Business Review; Research and Development R&D; Society of Automotive Engineers, Inc., etc.

(6) Participation in panels and conferences of such organizations as: NAE, NAS, OST, IEEE, ASCE, etc.

(7) Examination of current pieces in the open literature as authored by others.

SCOPE AND PURPOSE

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ABSTRACT

As an introduction to the overall meeting, this paper states the scope and purpose of the meeting, what the initial aim is to discussions and problem solving. It deals with the matters to be covered as well as the matters which may arise during presentation and discussion. This conference is an experimental conference in which, hopefully, solutions to pollution control technology can be recognized and the interrelationships between each pollution type are dealt with in a manner whereby an answer or solution can be presented. This conference will address the basic steps involved in pollution control technology assessment. The conference itself provides a means for communication among some of the interested parties.

TEXT

Environmental problem-solving has been a learning experience. Through direct approaches to pollution problems, many technological solutions have been developed to control pollution. This progress, however, has enabled us to see the elements of environmental quality more clearly and it is now apparent that we are better transformers of environmental problems than we are solvers.

This conference is an experimental conference. It is not concerned with water pollution control technology directly. It is assumed that water pollution control technology is or can be made available to allow the control of water pollutants to any degree desired. The scope of the conference is directed at the assessment of this water pollution control technology and with the identification of the secondary effects that are brought about in our attempts to achieve clean water. The introduction to the subject of technology assessment previously made has set the stage for the broader perspectives to be addressed. Through this conference we wish to explore the subject of environmental quality through an assessment of pollution control technology.

Solutions to pollution control technology begin with the recognition that there are many interrelated factors. The assessment of the impacts of pollution control technology requires an identification of those sectors that may be impacted by the technology itself and by the byproducts produced in the pollution control process. The assessment, by its very nature, requires effective communications and discussions among all of the principals involved. These include, of course, the scientists and engineers directly dealing with pollution control technology; social and behavioral scientists dealing with many of the human factors of the problem; economists directing their attention to the monetary costs and benefits of control technology; the legislators who establish the general goals for environmental quality through laws; enforcement agencies which set regulations; the industrialists and municipalities who are confronted with the need to control water pollutants; and, of course, the general public upon whom all of the factors impact. The attainment of improved environmental quality requires solutions to pollution problems that consider all of the impacted sectors. The final step in the technology assessment involves the recognition and the explicit statement of the environmental trade-offs.

This conference will address the basic steps involved in pollution control technology assessment. The methodology for pollution control technology assessment will be discussed. Stated simply, the methodology for technology assessment provides a means to explicitly address the interrelated elements of pollution control technology. This involves the identification of the media that may be affected by pollution control technology and a consideration of the cross-media impacts involved in the solution of any problem. In response to legislation regulations are set for one medium with little concern for the other media that may be involved. It is clear by now, however, that solutions to air pollution control problems often result with residuals that have an impact on water quality and produce solid waste disposal problems. In a similar fashion, sludges produced by wastewater treatment processes must be dealt with in an appropriate manner, otherwise air pollution problems from incineration can result or land must be allotted for disposal of these particular wastes.

In addition to the media, the various types of environments must be encompassed in the technology assessment. Each of the three broad environments--the physical, the biological, and the human environment--must be considered by itself and in relation to the others.

Problem understanding is the second major element to be addressed through this conference. The speakers on the program represent many disciplines with various points of view. It is expected that through these presentations, the many variables will be identified which must be faced in pollution control technology.

The conference itself provides a means for communication among some of the interested parties. While it is necessary to develop solutions to environmental control problems, the very understanding of the problem depends upon communication of the secondary and higher order effects by the impacted sectors. The alternatives to pollution control cannot be developed without communication among all impacted sectors.

It is now well recognized that environmental quality can only be achieved if there is involvement by the impacted groups. The final step, of course, of pollution control technology assessment is the commitment to take an appropriate action which maximizes the benefit to the largest number of people and minimizes the costs involved both from a monetary and an environmental point of view.

SESSION II: LEGISLATIVE MANDATE AND STANDARDS

Moderator:

N. Drobny

Battelle-Columbus Laboratories

INDUSTRIAL VIEWPOINT
LEGISLATIVE MANDATE AND STANDARDS

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ABSTRACT

The concern of industry over the numerous new regulations and legislation regarding their business is great. Each new regulation must be faced squarely and an attempt must be made to comply. In many cases this may be the beginning of the end for some companies, or in others a contradiction to an already established regulation. The industrial firms who must live with new legislation should be given a better opportunity to comply by being consulted by EPA officials and others in a lawmaking capacity before contradictive or unrealistic legislation is passed on to the industries, thus saving a great deal of money and distress for everyone concerned.

TEXT

I think Ray Smithson invited me here for two reasons. First of all, he knows that I consider that Battelle did an overall fine job on the water effluent guidelines study it did for the primary copper, lead and zinc smelting and refining activities, and secondly, I think he knows that I may not often enlighten but I often provoke discussion, so I think I fit into the panel.

We all, of course, must and do take seriously at this point all the environmental legislation that is affecting us. We are living with it every day. We seem to be besieged by armies of EPA people, state people, and local people, to the point that all this environmental legislation together seems to be the current version of the full employment acts of the 1930's. When executives ask me just what could happen to them under this legislation I usually tell them two stories, and it usually has a pretty good effect.

The first one is about the fellow who had been involved in nefarious affairs who got caught for the first time. I'm not suggesting a similarity between this man's activities and the executives of whom I speak. It was a new experience for him to go through the trial, and finally he was found guilty. He'd been asking his lawyer all the way along what happened next. After the guilty verdict came in, he asked what happened next, and the lawyer answered, "your're going to jail, I'm going to lunch." It illustrates the old axiom that lawyers never lose. Now we have in environmental legislation, with its many criminal penalties, a new potential loser in the executive who refuses to tkae these new laws seriously.

The other tale I like to tell executives is another criminal law joke which isn't applicable, but I wish it were. I've been told that this is based on an actual case. The defendant in his late fifties was brought before the judge after having been found guilty and sentenced to 20 years. He says, "Your Honor, I'm old and I'm sick; I'll never live out that sentence." The judge looks at him dispassionately and says, "Do the best you can."

Unfortunately, I feel that particularly in the water pollution field the best is often not enough. I think EPA and industry obviously take different viewpoints about what the best is, but I feel that there is an air of unreality about the way some of these standards are developed, and I'll touch on that a little later.

Since this is something of a free form panel without prepared talks, in which my role is to reflect industry's viewpoints, I'd like to touch briefly on several points. A speaker earlier mentioned environmental impact statements. The new vogue now is for state laws to add their own legal requirements for environmental impact statements. I think they're unmitigated disaster up to this point.

As an example, we applied in Montana for a variance last spring when certain standards were going to take effect on July 1. Of course, we'd been telling the state all along that they were unreal standards, so we did apply for a variance for the period ending June 1974. One year later we're just about to amend our statement to ask for another variance for the next year ending June 1975 because we've hardly gotten off the ground on our application for the first year.

The first thing the state did was get in the environmental impact statement game and that's taken the better part of a year just to mess around with that because in fact, they're practicing on us. They don't have the time, the people, the staff, the experience, and yet they're trying it. It's on the books as the thing to do and I think it's just another element of legislative disaster. One direct impact on industry is that every step of the way we're being asked for information. Our people are spending half their time in legislative offices, in the agency offices, and it's just a long wheel-spinning experience.

I for one in that particular case would have preferred to see us just sit back and say "Well, you passed the law, you passed unrealistic regulations, now go ahead and enforce them," and I think we'd have been much better off. I think we might have had the matter resolved by now, certainly at the trial level. I feel that industry, more and more, is finally coming to the realization that if it's convinced that a particular set of standards is just completely erroneous and unachievable and that they have a strong technical and legal position, they ought to just stand pat and litigate some of these things. I noted that EPA has some 400 pending cases, so clearly others share my views.

Sometimes the wrong companies test a law or regulation. We had a case in southern New Jersey where for years when you'd drive down the southern part of the Turnpike you knew that when you got to this area you had to watch yourself because a substantial cloud would often be covering the road. There were some accidents and many close calls due to poor visibility, yet it's that company that chose to fight the New Jersey regs, which had weaknesses which should have been stricken. Of course they lost, and we all went down with them.

So, although in that case the regs were very weak and very bad in some respects, bad cases make bad law or sustain bad law.

Someone mentioned energy and the environment. I think economics, energy and the environment are becoming much more closely intertwined and appreciated. Though not directly on point, I'd like to read a couple of sentences from a news clipping reporting on a hearing before the the New Jersey Department of Environmental Protection on a proposal to build a two-unit oil-fired electric generating power plant on a 186-acre tract consisting of marsh, sand, and grass on the Raritan Bay. To the surprise of many, several hundred people showed up. They had an 8-hour public session, and with four or five exceptions everybody was vociferously in favor of the power plant, so I think things are changing. This was and is a rather depressed area. One fellow said after he had been listening to the opponents, "We've heard here what's good for the fish, what's good for the birds, what's good for the plants, but nobody has told us what's good for the people." This was a retired resident who was arguing in favor of the power plant. If you know that section of New Jersey, it's right at the bend down from New York harbor. It really is an awfully nice area but the conservationists picked it out as a wetland area and had it so designated. They're holding tightly to it, opposing any development of any sort in that area.

Another fellow at this hearing said, "This is a staged crisis; the problem is not ecological but economic. I believe in ecology where it belongs. This state and this area are industrial. We will never have a wild animal kingdom here. We need electric power. We need jobs. We need tax returns that can help us save and restore our towns." These were the local people who would be most directly affected, most directly impacted and they came out in force because people are finally coming to realize in states like New Jersey -- and the unions particularly are coming to realize this -- that the 8 and 9 and 10%, and in the case of certain construction trades 14 and 16% unemployment has some causes which you don't find in the newspapers. This reminds me that at a hearing last week in Washington a fellow from a chemical company said that EPA had publicly announced that only 30 plants shut down last year in the U.S. because of pollution requirements. He said that his company alone shut down 5 last year, and couldn't believe that his company was 16% of the national shutdown experience last year. I feel about the New York Times and its environmental coverage the same way certain Republicans do about its political reporting. We just don't get balanced coverage.

Getting back to employment statistics as they relate to environmental quality, union and others are starting to realize the connection, and you can detect this even in the New Jersey Legislature, which has rushed through many harsh measures in the past with little debate. To have the type of hearing I've reported on occur in New Jersey has been a severe surprise for some of the environmentalists, but I think economics are really coming to the fore.

People just aren't working through large areas of New Jersey in the construction trades. Many companies, making no fanfare about it, have been going elsewhere. My company is going to expand greatly our existing refinery out West rather than the one in New Jersey. Another copper company which has been in New Jersey for decades has announced it's going to spend $100 million in Texas and build a completely new refinery down there. So the New York metropolitan area is really getting hurt to the point where people are sitting up and taking notice.

As I said, in a forum such as this I usually try to provoke some discussion of differing viewpoints. I may succeed by stating my opinion that one of our big problems today is Senator Muskie. I think we all greatly respected his environmental efforts back in the late 60's. I took part in the hearings on the Clean Air Act in 1967 and 1970, and he was really on top of his subject; he really knew his stuff. He asked very searching questions, he was very close to his subject. It seems to me that since he was bitten by the presidential bug he's turned largely into a liability on this issue. I don't think he knows his subject well anymore. His interests may be elsewhere. I think other people are to a great extent writing his script for him. These are harsh words about Senator Muskie, but deserved when one considers all the good he could be doing. I think he is going to be the loser in the end because I think the pattern has to emerge that something significant has to be done with the Clean Air Act and the Water Act or we're all going to be in trouble economically in very short order. Just look at the growth in funded debt of heavy industry over the past several years.

One of our competitors announced recently a new smelter in New Mexico, and quoted some figures. Out of a $200 million capital cost, somewhere between 25% and 30% of that capital investment is going to be spent just on air pollution control; this is without even getting to the water area. On the energy end, something around 85% of the kilowatt hours forecast are going to be used to drive these pollution controls. Now if that isn't the tail wagging the dog I don't know what is. But this is the way things are going.

Permit me one more example. I like to give practical examples, especially when so many agency people are in the audience, for I can't help believing that some of the people in the agencies really don't realize what's going on in what we call the "real world".

Bunker Hill filed an affidavit in the toxic pollutant water hearings last week. Just to touch on a couple of essential points, their mine in the Kellogg, Idaho area has been there since 1885. They've just spent a number of millions of dollars in putting a new treatment plant in, which I gather everybody agreed is the best practicable control technology currently available. Even with it, Bunker Hill said they won't get anywhere near meeting the toxic standards being proposed. EPA says, "Well, evaporate. Build ponds and let it evaporate and move the sludge out." Bunker Hill says to do that it will take 10,000 acres, or a 16 square mile lake, for an evaporation pond sufficient to do that. The valley in which they exist is 9 miles long and a half mile wide. Even assuming they had the space, which they don't, and assuming that seepage is going to have to be controlled with an impervious liner, they said it would cost $397 million to do this. As I recall, that's more than the company's net worth, but these are the things that we face in these totally unreal requirements. Bunker Hill further says that using methods proposed by EPA would cost $13 million a year and use enough energy to support a 400,000 population, and still not meet their toxic standards. And so they analyzed everything that EPA proposes, and said in their affidavit that "implementation of the proposed standards would force Bunker Hill's operations to cease." 6,000 jobs in that area of Idaho is an awfully large percentage of the working force. 6,000 jobs would go, without considering the ripple effect, of course, on the whole area. And it's just sheer disaster that these are the things that would happen.

My own company in Anaconda, in Butte, Montana, alone would need a lake 7,000 acres in dimension, and with the impervious liner requirements costing somewhere between $30,000 and $50,000 an acre, you are talking of a quarter of a billion dollars. Amazingly, this overkill doesn't seem to bother many at EPA, who say, "Well, this is the thing you should do. We don't want an ounce seeping into the ground. We don't want an ounce being discharged."

I think the heart of the problem right now is EPA management. EPA is hiring some bright young men, who really want to dig in and find out what's going on. I'm really impressed with the caliber of the younger people over the last 12 to 18 months. Unhappily, EPA still has too many people at the middle management level who play what I call a "low number game". They just search the literature to find the lowest number they can find, though it may have evolved in a wholly different context.

These low numbers are publicly promulgated apparently with no sense of embarrassment. For a while we used to laugh and say they couldn't be serious, but we know darned well they are now. My company can offer a sad example of the number game on the air side. I read recently where the Foundry Association said that well over 300 foundries have shut down in the last 2-1/2 years because of air pollution requirements. We have a little foundry that serves our refinery in New Jersey. It operates 2 days a month on an average and it's in the middle of a lot of tall buildings where you really couldn't see it or the emissions from it from the boundary of our property. The test in New Jersey is emissions, not ambient conditions beyond your property line. So we spent $60,000 in installing what they agreed was the best technology. It didn't comply and totally unembarrassed they came back and said, "You control it to the standard or shut it down." We're still running. They haven't come after us yet. I think if they do we've got to just make a stand against such unreasonableness.

Getting back to my friend from the chemical company, and to the subject of legislation, there's a section in the Water Act which I call the blackmail provision. It very properly in the first part of it sayd that an employee can administratively raise charges that his employment was affected either by being terminated or substantially affected in some other way because of activities of his in the pollution control field against the company working to the detriment of the company. That's fine, a good provision. But it goes on to say that anybody who feels that his job was ended because of pollution control, or is threatened, can also initiate these administrative proceedings. Of course, the long and short of that is that when a company finally totes up the control bill that it's facing it just quietly shuts the place down and leaves, rather than blame pollution costs and face a bureaucratic nightmare. That's never counted as a closing due to unrealistic control demands. EPA says with some justification that usually these are old facilities, largely outmoded. Nonetheless, they had been operating for decades, producing products and offering employment.

Our plant in Perth Amboy has been there since the 1890's. We've spent capital rebuilding the tankhouses and various portions. They've been largely built inside but the darn place is 80 years old and we've been operating for 80 years, just as Bunker Hill has been mining for 85 years. There's been no devastation, no epidemics of this, that or the other in the way of health effects. These are the realities which must be put on the legislative scale and weighed before it's too late.

Getting back to the trouble with existing legislation, as I see it, I think that even EPA acknowledges today that timing is one of the big statutory problems. Toxic standards are supposed to be implemented and achieved in one year. That's an absurd requirement and I think even EPA acknowledges that's so. They are in favor of going to Congress and taking a more realistic look at it and putting in a more realistic schedule. But again, I say the low number game is a large part of the problem, and I think EPA middle and top management is essentially accountable for allowing this to develop. Most of the EPA top management are lawyers these days, from Mr. Train down. When standards such as have been proposed lately get to management, I find it hard to believe that they bring their people in and say, "Now, where did you get this number? Why just one number? Where does it come from? What's the reliability of it? Of the fellow who found it? Do you have confidence in the methods that he used? What does industry say about this? What do they say is achievable?" Every time I go to an advisory meeting or to a meeting at the EPA technical staff level, I ask, "Why can't you have a lawyer here to hear these things as we develop them?" They say, "Well, you'll have to take that up with legal counsel." That's what we've been trying to do! You just can't get a handle on EPA at its middle levels. It's a big amorphous blob. Many of the growing pains are understandable, but nonetheless frustrating. You go to a certain point with the technical people and they say, "Well, you have a point there, but that's outside my jurisdiction." You say, "Whose jurisdiction is it?" "Well, it might be So-and-so in this section, but of course, he left last month, or it might be So-and-so in that section, but he's in California." One complicating factor I'm convinced exists is a middle management level with bad emotional bias that really isn't giving the complete input to top management it should. A healthy skepticism at top EPA levels with its own staff input, and not just with industry's input, would be a favorable development.

How many of you had my experience? You have a man spend 16 days, maybe 2 or 3 people spend 16 days, getting up requested data, you send it in, and it gets buried somewhere. It never gets out of the files in Durham. You realize this later when you talk in Washington with an assistance administrator when he says, "I never heard of that."

I've used my allocated time. I hope my far-ranging observations and criticisms will stimulate a profitable discussion period.

HIGHLIGHTS OF LEGISLATION

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ABSTRACT

The FWPCA requires EPA to regulate the discharge of pollutants from "point sources" into our nation's waters. Federal control under the Water Act follows a two-phase process. First, standards must be set, telling each industry the general degree of pollution control technology that it must adopt. Second, permits must be issued for each specific plant discharging waste into the water, detailing in precise terms what each plant may discharge, and including a compliance schedule with an enforceable sequence of actions to assure that each industrial facility will meet permit specifications in a timely manner. Point sources discharging directly into navigable waters must meet discharge limitations based on effluent standards or water quality standards, whichever is stricter. These limitations are based primarily on the availability of pollution control technology. In general terms, existing dischargers must adopt best practicable control technology currently available by mid-1977 and best available economically achievable technology by mid-1983. In addition, new plants must install "best available demonstrated control technology", which under our guidelines is translating into a middle ground somewhere between the 1977 and 1983 requirements. Now that the implementation of the 1972 amendments to the Federal Water Pollution Control Act is underway, it is also useful to look at other Federal environmental laws to see how they may impact water pollution control. We have environmental legislation, proposed or enacted, covering such diverse problems as land use, the discharge of toxic substances, the protection of fish and wildlife, and others. The regulation of these problems could indirectly affect water quality, although the impact is not very significant in all cases. In some cases, however, portions of a bill can have a direct impact on water quality. The 1972 amendments to the Federal Insecticide, Fungicide, and Rodenticide Act, for example, provide a clause that specifies general environmental protection. The House version of the Safe Drinking Water Act of 1973 expands the control of the Federal Water Pollution Control Act amendments of 1972. The Clean Air Act has requirements which, if mismanaged, could potentially cause water pollution problems. EPA is aware of these interrelationships and prevents negative impacts through the implementation of our standards and regulations.

FWPACA AMENDMENTS OF 1972

On October 18, 1972, Congress passed the Federal Water Pollution Control Act Amendments of 1972. It provides new enforcement tools for combating pollution and increased Federal grants for construction of waste treatment facilities and authorizes additional funds for research into problems and solutions to pollution. In enacting the new legislation, Congress stated that it is the national goal that the discharge of pollutants into navigable waters be eliminated by 1985. As an interim goal, it is stated that there be attained by July 1, 1983, water quality which provides for the protection and propagation of fish and shellfish and provides for recreation in or on the water. In order to achieve such goals, the Act requires establishment of effluent limitations based on technology for the achievement of "best practicable control technology currently available" by July 1, 1977, and "best available treatment economically achievable" by July 1, 1983. These effluent limits apply to point sources discharging to navigable waters.

Permit Program

A major facet of this law was the establishment of a new national permit system called the National Pollutant Discharge Elimination System (NPDES). Under this program, industrial, municipal, and other point source dischargers must obtain permits setting forth specific limitations on the discharge of pollutants into the navigable waters of the United States.

As of April 15, about 900 major permits and over 5,000 minor permits have been issued.

State Approvals

This new permit system is national in scope, involving both Federal and state participation. The objective is a state administered permit program.

We have approved 9 states to operate the national permit program. They are Connecticut, Vermont, Michigan, Ohio, Wisconsin, California, Oregon, Washington, and Delaware. Hearings have been held on 4 others: Nebraska, Montana, Mississippi, and Georgia, and approval of these additional 4 states is anticipated. Another five to seven states should be approved by September of this year, bringing the total to about twenty.

We and our regional offices are working closely with states to get them to take over permit issuing responsibility, and in many states, joint programs with EPA for permit issuance are being carried out even though the state has not requested formal approval. We expect that by the end of this calendar year about 25 states will have received formal approval.

Permit Requirements

The basic requirements of the permit program, such as final implementation dates and effluent limits are consistently applied nationwide regardless of whether a state or EPA is running the program. Every discharger qualifying under the point source and navigable water definitions must apply for a permit if it has not already done so under the first national discharge permit program established by Executive Order 11574. The 1899 Refuse Act was the basis for that program.

Permits issued under the NPDES have a basic format of effluent limits, a compliance shcedule, and monitoring requirements. The 1977 and 1983 dates are targets to be viewed as the outside limits for compliance. The Act envisions that in meeting effluent limitations, there may be stages of compliance described as the attainment of levels of substantial improvement even before these legislative dates.

The compliance schedule may contain dates for achieving certain levels of progress such as preparation of engineering reports, final construction plans, beginning and completion of construction, and finally, operation of facilities. Interim dates and requirements are specified in the permit as a means of monitoring progress and minimizing slippage. For each interim date, the permittee must submit a written notice of compliance or noncompliance with the interim requirements. Where such interim dates may not be appropriate, reports of progress will be required at least every nine months.

The permits may, therefore, have more than one set of effluent limits. Limitations may be expressed as concentrations where the rate of pollutant generation is not directly linked to the production effort, such as in mining, or where other requirements, such as toxicity, apply. The effluent limits are described in terms of average and maximum kg (lbs.) per day. They are based on national effluent guidelines established under the Act or water quality standards, whichever is more stringent.

Best Practicable Control Technology and Best Available Technology

The new Act charges the Administrator with the task of publishing regulations providing "Guidelines" for uniform effluent limitations for point sources from industrial categories. These effluent limitations reflected in the permits are the ones which shall require the application of the Best Practicable Control Technology Currently Available for the 1977 target date and Best Available Technology Economically Achievable for the 1983 target date. Three things are identified in the regulations.

First, they give meaning to the terms "Best Practicable" and "Best Available" when applied to the various categories of industries. In defining "Best Practicable" and "Best Available" for a particular category, such factors as the age of the equipment and facilities involved, the process employed, the engineering aspects of the application of control techniques, process changes, and non-water quality environmental impact (including energy requirements) are taken into account. In assessing "Best Practicable Control," a balancing test between total cost and effluent reduction benefits is made. "Best Available" technology is the highest degree of technology that has been demonstrated as capable of being designed for plant-scale operation, so that costs for this treatment may be much higher than for treatment by "Best Practicable" technology, so economic feasibility is a factor in interpreting "Best Available" treatment. Cost effectiveness for either standard is to be confined to consideration of classes or categories of point sources and will not be applied to an individual point source within a category or class.

Second, having interpreted "Best Practicable" and "Best Available," guidelines are being published which will determine what "effluent limitations" are to be imposed on dischargers. In these guidelines, the degree of pollution abatement attainable through the application of the "Best Practicable Control" and "Best Available Technology" in terms of amounts of constituents and chemical, physical, and biological characteristics of pollutants are identified. These guidelines can then be applied in setting specific effluent limitations on dischargers.

Third, the regulations identify control measures and practices to eliminate the discharge of pollutants.

We have issued final guidelines for 21 industrial categories,* and others (such as Timber, Dairy, Pulp and Paper, Builders Paper, and Pertroleum) are under a definitive schedule for finalization prior to publication in the Federal Register. Not later than July 1, 1977, publicly-owned treatment works must meet effluent limitations based on "information" which the Act requires the Administrator to publish. The "information" describes the degree of effluent reduction attainable through application of secondary treatment. This "information" was published by EPA in the Federal Register on August 17, 1973. NPDES permits are also required for publicly-owned treatment works.

Water Quality Standards

The new Act includes the concept of water quality standards in 1977 and 1983 achievements. Water Quality Standards which were adopted and enforced under the old FWPCA for interstate waters continued in effect and could be updated, and new ones were to be established for intrastate water bodies where not previously adopted by the states. This revision process (303(a) and (b)) is essentially complete. If water quality standards cannot be protected by the application of best practicable control technology for industries and secondary treatment for municipal wastes before 1977, then effluent limitations will be set which will protect water quality standards. Before 1983, if best available treatment and its equivalent for municipal facilities will not contribute to attainment of water quality which will protect public water supplies, agricultural and industrial uses, protection of a population of fish and wildlife, and allow recreational activities, more stringent effluent limitations are to be imposed. The review and revision process which will ascertain whether current water quality standards provide this protection will take place between October 18, 1975, and October 18, 1978.

OTHER ENVIRONMENTAL LEGISLATION

Now that I have described the implementation of the National Pollutant Discharge Elimination System Permit Program, I would like to discuss other environmental legislation and how it can impact water pollution control.

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* Fiberglass, Beet Sugar, Cement, Feedlots, Rubber, Flat Glass, Phosphates, Ferroalloys, Asbestos, Electroplating, Meat, Inorganics, Cane Sugar, Plastics and Synthetics, Grain, Fruits, and Vegetables, Fertilizers, Non-Ferrous Metals, Leather, Soaps and Detergents.

Federal Insecticide, Fungicide, and Rodenticide Act and its 1972 Amendments

This Act provides an excellent example of how environmental legislation can include provisions that protect the environment from any harmful impact that may result from its implementation.

Under the FIFRA and its amendments, pesticide regulation is accomplished basically through the registration process. To obtain registration, a manufacturer must submit data to EPA to show that: (1) the product would be effective for the intended purpose when used as directed and (2) label warnings and cautions when followed are adequate to protect man, livestock, wildlife, and the environment.

Several sections of this Act provide, through our regulations, specific requirements that prevent harmful impact to the environment. These are Sections 7, 3(d), 4, 8, and 19.

Section 7 deals with the registration of establishments and specifies which establishments must be registered, the procedure to obtain registration, the requirement that the registration number must appear on the label by October 21, 1974, and the report requirements for registered establishments.

Section 7 was incorporated in the new pesticides legislation as a result of the Mississippi River fishkill which illuminated the need for a government agency to be empowered to require information on the location of establishments engaged in pesticides activities. This knowledge, plus the mandatory identification of the establishment's registration number on the label of each pesticide product, enables Agency employees to determine the producer of the pesticide and the precise location in which it was produced.

The pesticides production, sales, and distribution information acquired from submission of producer reports will provide the Agency with a national profile of pesticides activities and will thus enable it to develop a more effective enforcement program so as to minimize any adverse environmental impact that might arise from misuse of a certain pesticide chemical.

Section 3(D) "classification" provides further protection to the environment. This involves classifying pesticides for general or restricted use. EPA must clearly define what criteria will be applied in identifying those products which may cause an "unreasonable adverse effect" on the applicator or environment. Two major drafts have been completed and distributed to interested parties.

Section 4 "certification". Acute health effects and localized environmental effects are largely associated with the improper handling and use of pesticides by the individual applicator. Certification can be a basis for ensuring that pesticide users have sufficient practical knowledge to protect themselves and others from acute health effects and to prevent the most common types of localized environmental damage. Our proposed regulations require such knowledge for certification.

Section 8, "maintenance of records". Our proposed regulations require records on the disposal or storage of pesticides and their used packages and containers and the disposal and storage of excess amount of pesticides including, without limiting the foregoing, the method or methods of disposal, date or dates of disposal, site or sites of disposal. Also required are records of any factual information regarding any adverse effect on the environment by any pesticide.

Section 19. "Pesticides and containers; acceptance, disposal, and storage". In our proposed regulations we discuss procedures not recommended for disposal of pesticides and containers. One of these disallows water dumping or ocean dumping, except in conformance with regulations developed pursuant to the National Marine Protection, Research, and Sanctuaries Act of 1972.

In another part of these guidelines, the effects of subsurface emplacement of liquid by well injection and the fate of injection materials is discussed. It states that "well injection should not be considered for pesticide disposal unless all reasonable alternative measures have been explored and found less satisfactory in terms of environmental protection."

The Clean Air Act

The implementation of this law provides us with a specific example of how compliance with some of its requirements could potentially cause water pollution problems. There are two available methods to meet EPA's SO_2 (sulfur dioxide) standards: the use of low-sulfur fuel and flue gas desulfurization (scrubbers). The use of scrubbers produces a sludge waste which could be disposed in the water. Any such waste disposal into navigable waters is, of ccurse, controlled by the 1972 amendments to the FWPCA. However, in this case the sludge produced is a manageable problem and can be disposed of properly either through the use of a lined disposal pond or a solidification process. In addition, Judge Tamm, in Essex Chemical Corporation v. Ruckelshaus, quoted Judge Leventhal's statement in Portland Cement that "we cannot imagine that Congress intended that 'best' could apply to a system which did more damage to water than it prevented to air" as particularly apropos in a discussion of the issue of the disposal of sludge produced by scrubbers.

The President, in his message to Congress when sumitting Reorganization Plan No. 3, 1970, which created EPA, described as the primary reason for establishing EPA the need to interrelate and coordinate all our anti-pollution efforts in order to avoid the harmful side effects some control actions may produce on the environment. He wanted to ensure that when a problem arises such as the potential water pollution of the wastes produced by the scrubbers, there would be sufficient coordination within one organization to prevent this potential from becoming an actual problem.

The Drinking Water Act and the Ocean Dumping Act

Not all environmental legislation has mandates which if mismanaged can potentially cause a negative impact on some other area of the environment. The proposed Drinking Water Act, for example, would actually expand our current water authorities. The House version of the Safe Drinking Water Act of 1973 provides for a comprehensive state underground injection control program and provisions for a standby chlorine allocation program for drinking water and wastewater treatment. All three versions of the bill, the Senate version, the House version, and the Administration's version provide for more Federal supervision and control of drinking water than there has ever been in the past.

The Federal Marine Protection, Research, and Sanctuaries Act, better known as the Ocean Dumping Act, is another law that expands our authorities to control water pollution. The law generally prohibits dumping material into the territorial sea or the contiguous zone of the United States without a Federal permit. In addition, a person, regardless of his nationality, may not depart a United States port with material intended for dumping anywhere in the world's oceans unless he has first obtained a Federal permit to do so. High-level radioactive wastes and radiological, biological, and chemical warfare agents may not be dumped or transported for dumping by persons subject to the first two provisions I just mentioned. As of last week, fifty-five ocean dumping permits had been issued, and four enforcement actions had been taken.

THE ROLE OF DOMESTIC COUNCIL AT THE WHITE HOUSE

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The Domestic Council in the minds of many may be unclear as to its official duties, but this body of men is important as behind the scene brokers who get to the President and help him formulate his domestic policies. How policy is made and how legislation is acquired or vetoed is an intricate task, and one that takes time, knowledge, and an understanding of all facets of the immediate matter. This process is explained as Mr. Norman Ross sees it from his view point as Associate Director of the Domestic Council.

I'd just like to tell you how we go about making policy or go about not making policy with respect to various pieces of legislation and legislative initiatives. I'd like to familiarize you with the structure of the Domestic Council as it appears in a recent issue of the Nations Business. "We are behind the scenes brokers, the little known, low key guys that get to the President and help him in the formulation of his domestic policies." Now the actual Council itself, the Domestic Council, consists of the President, Vice-President, the various Cabinet officers with the exception of the Secretary of State and the Secretary of Defense. These two Secretaries serve on the National Security Council. Also serving on the Domestic Council is the Director of the Office of Management and Budget, Administrator of the Veterans Administration and the Administrator of the Environmental Protection Agency. This group has a staff currently consisting of 13 professionals and it is these professionals that have the responsibility of looking at the various initiatives that are raised throughout the Federal Government involving domestic programs and putting them together in a coherent way to be presented to the President, to the Congress, or to the general public. Now, we receive input for the development of these initiatives or these recommendations that go to the President via the cabinet officers and we operate on a system in which the Cabinet officers actually run the show. In order for these Cabinet officers to do this we have established a number of Domestic Council committees in various substantive areas. One that you are probably familiar with in the area of natural resources, environment, is chaired by the Secretary of the Interior, Roger Morton, and it's co-charied by the Secretary of Agriculture, Earl Butz. Sitting on this committee are those agency heads that have programs in the natural resources and environment areas. The Administrator of the Environmental Protection Agency, Secretary Dent of Commerce, NOAA being in that particular group. The Secretary of Army, Corps of Engineers, also is included as well as the Chairman of the Council on Environmental Quality, Russ Peterson. Then we have various smaller groups that look at individual problem areas. For example, in the development of the administrations position on the Clean Air Act, just what amendments should we, in fact, think about, if amendments are, in fact, in order. It's a very basic question and questions like this we give to these committees to do the necessary technical work on. To do the necessary leg work to make recommendations to the chairman and then the chairman make recommendations to the President. Now what are some of the things that we look at?

There is the general structure and these committees are generally chaired by the various assistant secretaries that have responsibilities or administrators in that particular area. The one on air quality that I just mentioned is chaired by, when he was here, Bob Samsom; now chaired by Roger Strelow in EPA. We have others on world food policy; we are looking at the critical commodity shortages, water resources and we are thinking about forming a new one on climate with the National Science Foundation, and in the Department of Commerce, the National Oceananic and Atmospheric Administration. So this is the structure by which we go about our day-to-day work.

Now what are some of the things that we look at when we are attempting to decide on the posture or direction to take in the formulation of national legislation? One of the first things we look at, is existing legislation that either may mimic that or legislation that has expired and we'll look at what do we want to do that's different, if anything. For example, in the Congress of this session, we are looking at legislation on reverse commodities. I'll use this as an example. In this particular case we are looking at the renewal of legislation dealing with sugar, for example. Now, the Farm Bill of 1973 laid a new policy direction for dealing with all agricultural programs. That is, we are now moving toward a free market system. In other words we are going to get the government out of the business, a very basic kind of an approach. The President had some problems with the farm bill, administration signed it however and we are working with what we have. Now, it's time for us to look at the other commodities which were not in fact included under that very broad mandate.

Sugar is an example so we look at the question and then at the time we have to recommend legislation. Congress has asked us for our point of view so we ask ourselves some very basic questions. What problems did we have with the old legislation? Well, one, it's old and therefore it's not consistent with what we've done all along. These are the kinds of problems. We don't have the free market dictating a price for example. We have problems with that. They talk with Cuba. We have problems with employment looking at where sugar is in fact marketed here in the United States what is, in fact, wrong. So we ask ourselves not only what we've done before but we also ask ourselves and force ourselves to look at the current economic situation with respect to sugar. The price of sugar is very high as you well know on the domestic market and the world market. So we ask ourselves the economic questions that relate to any piece of legislation. Then we ask ourselves a very difficult question. The question that is often very elusive these days is that of the political ramifications of the process and in this political ramification we like to think that we use a very systematic way. We like to think that we do research and we really use it. We look at who is going to raise opposition to it and that's a research project. Then we go to the various departments, in this case the Department of Agriculture, and say who would you think would vote for that particular bill, who would not vote for that particular bill and what impact would this have on whether or not we'll get it, what impact would this now go on any variations there may be because we were given a position.

Now in this particular bill, the Sugar Bill, there were a number of recommendations for having sugar be treated like every other commodity and make it inclusive under the philosophy of the free market approach but then we thought about those sudden Democrats that this means a lot to, we thought about the difficulties of actually pushing a bill through this year and so put all this in a little hopper and we came up with the answer that it's best not to change sugar legislation this year.

We do the same thing on environmental legislation. We do the same thing on any piece of legislation. We do the same thing on any piece of legislation that we, in fact, look at and almost always there is not unanimity with respect to a given recommendation. Verse, agency has verse secretaries who will vote depending upon (1) the person's feelings, (2) the bureaucracies, and (3) they just don't really understand the case. And we did the same thing or this kind of thing year before last when we were looking at the course to take with respect to solid waste. Whether or not we'd let the act expire, whether or not we would revise the act, whether or not we would put anything up in place of it. We've just completed the same kind of internal process with respect to amendments to legislation, the need for them. The Clean Air Act, for example. How we went about formulating our national policy with respect to the Clean Air Act. This is a more difficult thing to do primarily because of the track record the administration has had with respect to the environment. Now the environmental movement came about in '69 and '70 and '71 we were really going full steam ahead. We have some very basic pieces of legislation during the current Administration, there were some 20 bills introduced to do various kinds of things with respect to improving the environment from purely grant research, the establishment of various agencies through Executive Orders or through Acts of Congress, cleaning up our air and our water, pesticides, noise, and you name it. So it was very difficult to do this because the first thing that we hear in looking at various positions to take with respect to legislation is that of the public, the public apathy and that's another very important role in any kind of national policy--just how the public is going to feel.

The question is asked, how will the public take this? and those that have been interested all along in clean air and clean water will look at this if we were to change as an affront, as an attack. We have lost our credibility with respect to the environmentalists and we are backing away from our historical positions, and that is not the thing to do. So then what can you use to balance that, recognizing that there is a problem? Then we look at the problem itself. It just so happens that during the last two quarters we were in a pinch for various kinds of petroleum products; oil embargoes or lack of refineries or for whatever reason, we just didn't have enough fuel and there were long lines, so the phrase was coined right along that we are experiencing an energy shortage and therefore we should do something about it. The general public initially didn't have this feeling so we didn't take any action on it. We recognize that as a problem, we want to negotiate with the oil-producing nations and we are going to see about using that approach as a method of solving the problem. It didn't quite work. We were able to get some relief from the lack of shipment of oil but it wasn't enough. So then we decided on what other alternatives could, in fact, be used. Before going the legislative route we will try using what we refer to as our jawboning strategy. First, we are going to go out and we're going to tell the general public that you are really going to have to turn down your thermostat, you are going to have to wear a sweater or you're going to have to car pool. We'll have to convince the general public that conservation efforts are important and they are in fact, necessary. Secondly, we are going to have to work on the industries. The public must tell the industry that they are going to have to do their part. Recognizing that this is a capitalistic society, that's a basic problem. That s a very difficult kind of thing but nevertheless this is a part of our strategy, our jawboning strategy before going the legislative route. We tried those things and now we have an assessment period in which we look at just how effective they have, in fact, been and based upon that assessment in this particular case, we were able to convince ourselves that the strategies used heretofore are not as effective as we needed them to be.

So what else is available to us? We listen to what the industry is saying, and they say that the reason for the current problems that we are having with respect to energy center primarily around the unrealistic, the very very rigorous environmental controls that have been layed upon us. Well we ask the question, "Well, how do you arrive at this conclusion?" (1) The technology has not been demonstrated, the technology is not in place for us to do all these kinds of things that the current laws mandate. That is, we don't have those black boxes that we can tag on the end of our smoke stacks to clean up all of the particulates and the sulfur oxides and the other polluntants that are eminated therefrom. We don't have the technology without going out of business to plug something on the end of pipe to prevent the discharge of deletery substances into the water, for example. You are going to just run us out of business so we listen. Then we ask the legislature, the governors. The governors are very syspathetic to the point of industry and to their constituencies. They say we've really got to do something about these clean air laws, these water laws or the environmental laws because they are just not workable and we need more flexibility, we need more variances. I can't afford for you to close down Los Angeles because of the presence of nitrogen oxide, smog or other harmful polluntants. I'm not convinced as a governor that the technology exists for me to tag on a converter to my car and I never want to tag on a converter to my car to clean this up and it's just too much of a problem so you've got to do something about this Federal government because you are the only one that's smart enough to do this. We tell them, "Write to your Congressman". We go back to the drawing board and we put all this together and we come to the conclusion that we've got to do more. We've tried to jawbone, we've tired to look at this administratively, we've talked to the governors, we passed our support, we've tried to turn a switch on at some times, turn a switch off at other times to help with these problems and it just hasn't worked. What are we going to do? Well, maybe the only thing to do is, in fact make new legislation or to amend the legislation that is currently in existence and boy, when you come to that point then you really, are committed.

The administration will amend the Clean Air Act then it's on the front pages. Then the Congress in also attempting to address the problem and they will amend the Clean Air Act or they will amend various other pieces of legislation for political reasons or for reasons of recognizing that a problem exists so that's the case in which they beat us to the punch and they have amended the law, the Clean Air Act. So we've got them interested in the Clean Air Act and then the legislation is sent to the President. We really want them, boy, this is really great. However, we really want some other things too. By the way, since you are thinking about helping us out, we want a new bureaucracy to help manage this broad problem of how to go about being independent with respect to our energy needs by 1980. Congress sends down a bill to the President that has all this in it and we look at it and say, yes there is the Clean Air Act amendment. Did we want it? No, we didn't really want that one, here is the agency that we really want, wait there's a problem here, it's against my basic philosophy of rolling back prices for oil, I just can't sign that, you see. So then you say. Well, please Mr. President, you know we've got all these other things in there, all these other goodies. Well, we really can't -- cross that out. So we veto the legislation so so we're right back at the start again. So we go up again and say, guys, you really did a good job but those windfall profits you've got to take out of there and then we have all these other nice things, and by the way since you are doing it, what about those bills on reclamation that will all help with this overall problem? Most national legislation is so broad in scope that it cannot really be compartmentalized, even if you look at health insurance or man power or housing, the issues are interrelated and sometimes closely knit.

So in looking at legislation, we look at the remifications each individual piece will have on the whole system and we try that approach. We try to come up with what we refer to as a comprehensive piece of legislation to solve our needs and we try that. We push that and we see what happens. In many cases such as in the Clean Air Act because of the technical problems here, we've had some very basic technical problems that we can't just stand up on a soap box and cite unequivocally that we have the answers to it. For example, in the area of controlled technology for the sulfur oxides. We just can't say unequivocally that the technology has been demonstrated and is in place to do these kinds of things, therefore you don't need some leeway. We cannot say that technology is in fact in place so that we can, in fact, meet the auto emission standards. We need more time. We need more flexibility and the pieces so we try the comprehensive approach to take care of all these problems at one time. In many cases it works and in other cases we fail and this is one case in which we actually failed to get a handle on the Clean Air Act separately and there are still many bills up on the hill that will address this and related problems, but they are not such that we can really say, boy these are the ones we want and these are the ones we don't want.

Now we are going to be doing the same thing with respect to the amendment to the 1972 Water Pollution Control Law. We've got some very basic national policy decisions to be made. Some of these decisions are going to be forced on us by external means. For example, the Supreme Court has recently agreed to hear a case with respect to the so-called impoundment of money for waste water treatment facilities. The court will hear the case from the court circuit and the case from the New York, Ruckelshaus versus the defendent, the environment. So we are now asking ourselves the question, why does he have to spend all that money and what will it do to the economy? I might not do anything. We look at our track record, we look at the money that has already been authorized and ask the additional question, how much of that has been allocated and we see only a third of it out of a total of $1.6 billion that has been actually obligated so maybe the program itself can handle the outflow or the budget guide, the outlay. How much money and how fast it's going to be spent or drained from the treasury.

The next question we've got to ask ourselves is what are we going to do next with respect to water legislation? The need survey completed by the Environmental Protection Agency recently illustrates that there's just no way that we can do all that's needed within the allowable time of the existing piece of law, that we have to address that issue. What do we do next, do we amend it to allow sufficient time, do we amend it, spend the $9 billion that we haven't spent if we win the court case? What other kinds of things do we want to do different ? Do we have enough flexibility in our effluent guidelines, for example. The industries are saying this will run us out of business. Then we have in another corner a study that's being made to see if we can in fact meet the 1980 goals of zero discharge and see what the economics will be, see what the social implications will be. See what policy implications will be for new legislation, continuing legislation to amend it. Just to say forget about it is just impossible. Well all these kinds of things are going on and someplace in the universe before the

the 1975 budget, all this is going to come together and we are going to look at what we are going to have to print in the budget for 1976 and hopefully by then we'll have a handle on the effluent discharges, and what we can do.

We need to have signal from Mr. Rockefellow on how he is coming up to make any recommendations on meetings the standards, meeting the requirements of the existing laws. We need a chance to go out and jawbone with the government to see how well they are doing with basic planning. We'll talk to the researchers to see, if they have solved the problems of surface water contamination. We ask, have you looked at the difficult problems of solving the nonpoint sources of pollution? Just where do we stand? Do we need more money for this? Do we need more time for that? Is this going to affect the accomplishment of the goals that have been layed out already in the statutes or can we just forget about it? We ask agencies to do this, we ask consultants to do this. We go around to the various associations; the governors, the mayors, the counties and ask the questions. Not the question of funding because we always get the same answer so we stop asking, do you have enough money, how are you coming with building sewage, this kind of thing. No, there's not enough money, we'll never have enough but we ask ourselves the question, is the water getting cleaner and we've really been surprised. Last year we asked that question on a national survey and the answer was, no, the water is getting dirty, we need more money. We have now stopped asking that question, but those are the kinds of questions that we are asking ourselves now. The tempo is going to pick up and we have a very important part to be made on this piece of legislation for the 1976 budget, how much money we are going to spend in it? Really now is the time to think and talk about amendments to it, whether or not we are going to extend the act, what the Congress is going to do. If we do nothing we'll probably get it anyway. Are we going to take the initiative, what form and under what conditions? So those are the kinds of things that we look at, hopefully in a coherent kind of way, and looking at the directions to take, the decisions to be made with respect to the development of national legislation. Thank you.

CONGRESSIONAL OUTLOOK ON ENVIRONMENTAL CONTROL LEGISLATION

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ABSTRACT

This paper on the congressional outlook for environmental legislation was prepared from a transcript of a presentation made by the writer from notes at the Environmental Resources Conference On Pollution Control Technology Assessment. The paper is intended to review possible environmental control legislation in the areas of water, air, solid waste and radiation pollution. Particular attention is given to the immediate legislative outlook on water pollution control. The review of the legislative outlook on water pollution control is based upon a review of experience to date in the implementation of the 1972 Amendments to the Federal Water Pollution Control Act.

I always enjoy the opportunity to participate in meetings of this type. It is a privilege. It also serves a most useful purpose for members of the Committee staff to meet with professionals like yourselves to discuss environmental control legislation.

As you know, I do serve as one of the counsels on the Committee on Public Works of the House of Representatives. The Committee has jurisdiction in the House of Representatives over the Federal Water Pollution Control program. However, because of the division of jurisdiction in the House of Representatives, Public Works does not have jurisdiction as the Senate Public Works Committee does over air, solid wastes, noise, and radiation. This means, and I hope everyone understands what I'm saying, that I'm making somewhat of a disclaimer of special expertise on air, solid waste, noise and radiation. However, I will address these areas as well as water pollution.

This is necessary because there has been in the past a leapfrogging of legislation from the air bill, to the water bill, to the air bill, and back to the water bill. Each time it gets a little bit bigger with a few more golden nuggets in it for everyone. There has not been the type of coordination in my opinion between the environmental areas that there should be.

You know, in discussing the water bill, I've used a little anecdote in the past. I would like to review it with you here today. This concerns a plumber (and of course plumbers are in the news recently anyhow). The water pollution law and the resultant regulations are most complex and difficult to understand. Many areas of the government are burdened with similar problems. There was a plumber who wrote the Bureau of Standards that he used and found hydrochloric acid excellent for cleaning out clogged drains and wanted to know if this was safe to do. Well, the Bureau of Standards wrote back. They have bureaucrats there just like myself and other staff members in the Congress. They stated "Our studies and research reveal that the efficacy of hydrochloric acid for the purpose stated in your letter is without question, however, the use of it results in a corrosive residue which is incompatible with metallic permanence." This was to a plumber.

The plumber read this and interpreted it. He wrote back "I'm glad to hear that you think that my idea's a good one and you go along with it." The Bureau wrote to him again stating, "We must point out to you without qualification that we can under no circumstances assume responsibility for the resulting toxic and noxious residues from the employment of hydrochloric acid in plumbing uses to which you have put it. We must strongly urge that you resort to alternative procedures that will not have the deleterious consequences we alluded to in our earlier communication." Well our friend the plumber received this with joy. He read it and said boy that's a lot of big words and that's great. He wrote back one more time and said "Thank you very much for agreeing with my recommendation. I really appreciate it." The Bureau finally got smart and wrote him a letter saying "Stop using hydrochloric acid. It eats the hell out of the pipes."

Well, the plumber finally got the message. This is one of the problems that we have with the water pollution law. It is extremely complex and extremely difficult to understand. EPA hasn't always followed congressional intent. Also, even some of us who would like to think we are familiar with the law are having one terrific job with the regulations. There are a lot of i's that have to be dotted and in some respect I have been a little critical of EPA.

Not so much on the House side but certainly on the Senate side, every time EPA turns around and does something which doesn't have all the i's dotted, there is a request for GAO to come in and investigate. This has happened, I don't know how many times so far, several for sure. It's been threatened more. That hasn't helped the program.

You know we were talking about plumbers, here just a minute ago. There's one more little story I'd like to tell you about plumbers. There was a lawyer who had one heck of a problem with a drain pipe and he called in a plumber. The plumber came and he worked on it for one hour. The lawyer asked well what's the tariff, how much is it going to cost me? The plumber replied cooly, $50. The lawyer exclaimed, $50! Incredible, I've been to school for nine years and I only make $30 an hour! The plumber looked at him and said "I know, I only made $30 an hour when I was an attorney."

So this is a good time for most plumbers. Everywhere but Washington, that is. I know in downtown Washington there are a lot of plumbers running around unemployed right now. At least three of them were attorneys and there was a public relations man in the group too.

But all that aside and back to the matters before us, there is one most important piece of environmental legislation currently going through the Congress. It doesn't fall under the guise of environmental legislation but rather it's called House Resolution 988 which would reform the structure, jurisdiction, and procedures of the House of Representatives by amending the rules of the House of Representatives. H. Res. 988 would establish a new committee on energy and environment which would have legislative jurisdiction over energy and energy resources, the environment, including environmental policy, land-use planning, coastal zones, air and water quality, noise control, ocean dumping, and disposition of solid waste and conservation of resources. It would have jurisdiction over all water, including research and development but not water resource development, navigation and dams, etc. It would include irrigation, reclamation, and possibly deepwater ports. The Committee would have jurisdiction over public lands, parks and recreation, and wildlife.

As you can see, as far as the environment is concerned, the Committee on Public Works now has jurisdiction over water pollution, Interstate and Foreign Commerce has air, noise and solid waste. Interior has land use. Different committees have different jurisdictions. Because that creates legislative problems in the Congress and because it detracts from the quality of legislation this proposed legislation could have far-reaching impacts. The fragmentation that currently exists in the Congress and the House would be eliminated and it would be possible for the environment committee to develop comprehensive and lasting expertise in the area. Right now we can't do that. It's just impossible. OK. So I'm an attorney and I'm an engineer and I've spent a lot of time on water pollution. However, for the last six months I've spent most of my time on water resource work, disaster relief, deepwater ports, and various other assorted things, not water pollution.

You all are the professionals. Most of you spend 100 percent of your time working on water pollution control. In Congress the staff who helped the members write the water pollution legislation, once the bill is passed, has to turn to other things, thereby losing continuity.

I think the change in the organization of the House could have very important, very far-reaching, and very beneficial results. The attorneys and technicians available to the Congress would be able to use their water pollution background or air pollution background in other environmental areas and vice versa. There would be a greater recognition of the fact that you can't have water pollution legislation without considering air pollution, solid waste disposal, noise, etc. The quality of the work product might be improved substantially. But in any event, it's a good proposal supported by members of our Committee. I hope all of you would support it.

Now, let's talk about the 1972 Amendments to the Water Pollution Control Act. When the committee was working on the amendments, it was felt by all involved in their development that they were a significant advance in the field of water pollution control. Further, it was felt the conference report that the House and Senate worked out together was superior to the bills that were put out by either the House or Senate. The bill was complex and there were problems but in general it was pretty well supported.

As you know, good judgment is the fruit of experience and experience as often as not is rooted in bad judgment and in the past perhaps in some of the water pollution control programs there was some bad judgment. Perhaps there may have been some bad judgment in the development of the existing 1972 Amendments. That was a time of very strong environmental pressures. The Congress is reviewing the law and is working on it right now. We have held hearings. They are expected to resume.

The Water Pollution Law, when it was passed, was based upon four cornerstones and one keystone. Somewhere along the path of implementation perhaps a couple of those were misplaced. The cornerstones were comprehensive planning and much of that has gone by the wayside; adequate financing and we just heard some comments on that; research and development for the future, that's probably in pretty good shape; and a workable law competently administered by EPA. The law was extremely complex, EPA has had some real growing pains in implementing it so some of the cornerstones are a little bit shaky.

The keystone to this new legislation was even more important and that was the combination of cooperation between the Federal agencies and the state and local governments. I wish I could stand here today and say that I was completely convinced that the keystone was solidly in place and was holding the program together rather than sometimes working as a millstone. There has been an awful lot of consternation between the states and EPA as to who's doing what and to whom. We worked hard on this legislation and one thing that we really spent a lot of time onwas to try to get the permit program out to the states. Now we had some conversations this morning that so far permit programs have been approved for only 9 or 10 states. There are reasons for part of this and these reasons are the complexity of the regulations piled on top of the number of regulations that the law requires. Let me emphasize, one thing Congress really wanted was to get the confounded permit program out to the states, because that's the place where there was some hope of having the number of people available to do the job. So far, a year and a half later, there are only 10 states that are currently qualified.

The states must be allowed to participate and contribute. They need Federal support and encouragement. They aren't getting enough. We heard OMB a month or two back state they were thinking about cutting out program grants for the states. Well, on the one hand, the law says, "states, here's a big job to do, run with the ball." On the other hand, we have somebody saying, "no-no, can't have all the money". Some of the states are coming back in and saying, as I saw in a recent letter from Governor Tribbitt of Delaware to Russell Train, "clarify this for us if you will because we are considering forgetting state participation." Now, they have not dropped it and EPA has clarified the situation, but the State of Delaware for one was ready to back out and say, "Manage the damn program, we don't want it if you aren't going to help us pay for it." Well, part of that has been squared away but it's this kind of a constant consternation between the states and EPA or OMB that creates problems.

Now, what's going to happen as far as environmental control legislation is concerned in the next few months, next year. The Congress is sort of playing a little bit of a game right now with the administration. The age of the environment is in full swing but the pendulum is on its way back just a little bit. However, the Congress is reluctant, I think, to say, let's make some changes to ease up on environmental legislation. The Administration also is reluctant to say, let's ease up on environmental legislation.

In the water area, there are some amendments which may be necessary. We heard a few minutes ago about what's going to happen in municipalities in 1977 when the money's not available and they haven't done the job. Well, what's going to happen to industries on December 31, 1974, when they don't all have permits and are subject to citizen suits and 309 actions and everything else.

Congress is going to have to take some steps. Our Committee has asked EPA in recent hearings to make their recommendations on legislation. EPA is supposedly diligently working on these recommendations. It remains to be seen who will speak first, but somebody has to do something rather quick.

The law requires municipalities to have secondary treatment installed by July 1, 1973. When we were working on the 1972 Amendments we put in $5, $6, and $7 billion for three fiscal years for treatment works construction. At that time, the Congress was being sorely criticized by the Executive for putting in exorbitant numbers which were unreal because their studies said $14 billion was all that was needed. Two years later the next estimate came out, $60 billion. In September there will be a new estimate which I predict will be $100 billion. In February there'll be another estimate which may be higher than that.

We have a massive, massive, massive program, a lot of which revolves around nonpoint sources and combined sewers which are exorbitantly expensive. Nobody really has a real good idea of what to do about them right now. The money will not be available to provide 75 percent grants to all municipalities to do the job in 1977. If the money were available, the job wouldn't be done by 1977, anyhow because there are plants under construction right now that are going to take 5, 6, 7 years, perhaps, before they can be constructed.

Congress is going to have to do something about this problem. Whether it will be a moving back of the 1977 date for municipalities, whether it will be a giving to EPA discretion to waive that requirement for certain plants, or what form it would take I'm not prepared to say right now because I frankly don't know. I'm not sure what recommendations EPA will make. I suspect, however, it may be along the line of giving EPA some discretion.

What's going to happen on July 31, 1977, as far as industry is concerned? Again, I can't make a prediction but you've got to recognize that section 315 established the National Commission on Water Quality, which is chaired by Governor Rockefeller and which includes as its members Senator Muskie, Senator Howard Baker of Tennessee, Congressman Bob Jones of Alabama, Congressman Bill Harsha of Ohio. This Commission has the job of evaluating the impacts of meeting or not meeting the 1983 requirements for best available technology. This is not no-discharge; that's not part of 1983 per se. No-discharge is a 1985 goal which isn't mandated anywhere in the law. A lot of people have some misconceptions on that. It's not mandated anywhere. It's a focal point for planning; it's a focal point for research and development.

Let me be critical of EPA for a minute. I think EPA in the development of regulations has gotten carried away with what the Congress may have intended with regard to no discharge. We see a lot of regulations being promulgated with no-discharge as their basis. No-discharge, if it's practicable, if it's economic, if the economic, social, and environmental aspects can be met, is fine. Some sort of a balancing test was intended. But no-discharge by 1985 is a goal, a focal point for research and development. It is not a requirement. There are no words in that law anywhere that require no-discharge, in 1983, '77, '85 or any other year. EPA, as I say, has gotten carried away on that. However, as far as industry is concerned, I don't believe there will be significant changes in the law until such time as Governor Rockefeller's commission makes its recommendations with regard to 1983.

The President is required by December 31, 1974, to allocate the treatment works construction grant funds for fiscal year 1976. That means that Congress sometime this year, probably around September, is going to have to decide what level of authorizations will be available for treatment works construction over the next 1, 2, or 3 fiscal years. At that time we will probably have in hand, as I said before, a study demonstrating needs somewhere in the range of $100 billion. We will also have in hand a law which requires certain things to be done by 1977 and 1983.

The Congress is also faced with inflation, a deficit budget, and competing demands for the tax dollar. It's hard to say what's going to happen. It may not be realistic to expect too much in the way of expansion of the dollars for that program.

Another major issue that I think the Congress will address, perhaps this summer, is, what is secondary treatment for municipalities? Whether the Congress will do anything about it remains to be seen. It is a very very important issue. Secondary treatment, again, is required by 1977. The definition for secondary treatment was promulgated by EPA. It is completely lawful and is not inconsistent with the intent of Congress. It is questioned, however, whether the definition should be the same for all parts of the country. Congressman Johnson of California recognized this when the bill was before the House and put a statement in the record which was not sufficient in the face of the legislative language to provide flexibility. Look at places like Puerto Rico, Hawaii, or the Northern Pacific Coast, or Alaska where there is deep water or fast currents. Perhaps it's not reasonable at a time where dollars are limited to require a plant in Puerto Rico where there can be deep ocean outfalls, or a plant in Seattle, or a plant wherever it might happen to be to have secondary treatment when effluents are discharged into deep salt water. I don't know the best answer, but this is an issue the Congress may address.

There is another problem the committee may review. It was clearly intended to provide an incentive for industry to participate in municipal treatment works. There are, in fact, a number of incentives in the law to encourage industry to participate in municipal treatment works. Now, we hear varied arguments from different people saying the law itself is keeping industry from participating in municipal treatment works.

Probably, in June or July, the Investigation and Review Subcommittee of the Public Works Committee, will hold a series of oversight hearings on the impact of Public Law 92-500 on industry. We held a series of hearings on the impact on municipalities and the municipal program. The hearings will help inform the committee on how the law is being implemented. Also, they would be intended to help EPA have a better understanding of the committee's intent. In some areas, the intent isn't necessarily being realized.

Congress at some time is going to have to take a good look at subsurface disposal. Congress is going to have to take a good look at nonpoint sources. As far as Public Law 92-500 is concerned, most of the focus on nonpoint sources was for added research and development rather than controls. Congress may take a good look in the next couple of years at water quality standards and their impact. Another area is drinking water supply which Congress is looking at right now. Congress will be busy in water pollution control in the next few years.

Turning now to air pollution, we see similar problems. In view of the sluggishness with which air pollution control was being tackled across the country, Congress attacked the national effort to clean the air from two directions in 1970.

Reaffirming its intent to lower the pollutant level so that it has no adverse effect on man and his environment, Congress, in the first section of the Act directed EPA to set limits on the total amounts of six major pollutants that could be present in the air at any given time. In the second section, it ordered automobile emissions rolled back 90 percent from 1970 levels.

These directives were accompanied by tightened time limits and with a comprehensive schedule which regulates the implementation and enforcement of ambient air quality standards by the individual States. In doing so, public health and welfare rather than cost and other economic and social criteria remained paramount considerations. While levels of atmospheric contamination could vary with individual air quality control regions, they could not drop below the ambient standard. Emission standards for new sources by individual pollutant, special national standards for contaminants designated as hazardous, and the opportunity for citizens to sue sources and government agencies for noncompliance with the provisions of the Act were to provide added impetus for accelerated efforts to clean up the Nation's air and decrease further contamination.

Petitions to delay implementation, oversight hearings and court cases in the past three years have given a good indication of the areas for which amendments would be sought. Four areas in particular were singled out for dispute: ambient air quality; pollutant levels set by the standards; availability of control technology; and costs vs. benefits.

Mandatory maintenance of existing clean air levels, notwithstanding limits set by the ambient air standards, was tested and upheld in the courts in nondegradation suits. These decisions were based on the congressional intent of "enhancement" expressed in the Act. However, the split vote by the Supreme Court to uphold this decision which had been rendered by a lower court indicated that further clarification of this point by law may be necessary.

Disputes involving pollutant levels allowed by the ambient air quality standards, as well as emissions of individual pollutants permitted by the automobile standards and the new source regulations pointed up the uncertainties surrounding data indicating current and projected damage to public health and welfare. The issue of needlessly strict limitations was raised by polluters as well as by citizens and Members, and bills introduced to weaken the requirements on the grounds of insufficient evidence that current standards were necessary testify to the eagerness with which a study on health effects of air pollution, requested by the National Academy of Sciences by the Senate Public Works Committee, is anticipated.

When requesting a delay in standard enforcement, polluters have continuously and consistently cited the unavailability of adequate cost-effective control technology. Auto manufacturers have obtained a reprieve, possibly until 1978, with these arguments. Industrial sources and power plants, whether or not they were converting to coal due to the energy crunch, have been granted variances and delays on the same grounds. The drive to permit the use of tall stacks and intermittent control systems which disperse, rather than decrease, the pollutant load in the ambient air, is based on the same argument, despite the law's statement that emissions must be limited at the source.

The matter of abatement costs, their scope emphasized in EPA and other governmental estimates as well as by projections furnished by industrial polluters and by municipalities facing considerable changes when implementing existing regulations, has become a major issue. No reliable data of potential benefits of the expensive abatement procedures have come to light. Costs to the national economy and to the lifestyle of U.S. citizens if air pollution remained largely unabated were not presented in a convincing manner. These doubts were expressed in proposed legislation, in oversight hearings, and even in less than forceful action by EPA when confronted with violations of the law's provisions.

As the Act approaches its expiration date, it is becoming apparent that the issues mentioned will be expressed in amendments proposed in the Congress as well as by the Administration. Bills concerned with delays pending better and less expensive control technology, the waiver of standards until non-polluting fuels again are plentiful, mandatory consideration of costs involved, the prohibition of drastic control measures such as transportation control plans, and legalization of pollution dispersal methods are already on the books. Administration proposals include, in addition, delays in those State clean air plans found to have regulations which are more stringent than necessary to meet primary standards; replacement of emission or performance standards by design or equipment standards, i.e. Federal preemption to waive regulations of new sources in order to demonstrate new, equally effective, and cheaper control technology; temporary waiver of requirements to permit the use of coal by industry and power plants; and a hands-off Federal policy in matters of significant deterioration in areas with high air quality (although State and local governments could set standards preventing deterioration if they wanted to do so.)

The study on health effects of air pollution by the National Academy of Sciences, and a second report on costs and benefits should be ready in early fall, and will hopefully, clarify at least to some extent whether there is continued justification to base national clean air legislation primarily, and almost exclusively on public health and welfare considerations. The reports may also help to determine whether the law should continue to include requirements which are beyond present attainment, as an incentive to cause air pollution control to move forward.

Solid waste legislation receives attention from Congress. Federal involvement in solid waste legislation began with the enactment of the Solid Waste Disposal Act of 1965 (P.L. 89-272). The limited research authority prescribed under the Act for developing solid waste disposal technology accentuated the need for new legislation. The passage of the Resource Recovery Act in 1970 (P.L. 91-512), changed the emphasis of the federal program from solid waste "disposal" to solid waste "recovery" and "recycling".

According to the National Center for Resource Recovery, "one of the motivating factors in the creation of the Resource Recovery Act of 1970 was to assess the effects of recommended programs and policies prior to implementing them. Comprehensive studies on a wide range of policy-related topics were deemed necessary, in order to establish a firm basis for federal approaches to resource recovery and the field of solid waste management."

While the Resource Recovery Act lacked standard setting and enforcement powers, the Act did require that special studies and demonstration projects on recovery of useful energy and materials be undertaken. In addition, it provided grants to the States and municipalities for resource recovery systems and improved solid waste facilities. Six demonstration projects throughout the country are currently being funded by the Environmental Protection Agency under the Resource Recovery Act.

In the major study required under the Act (Report to Congress on Resource Recovery), EPA concluded that "there has been sufficient technology development to allow extraction of materials and energy from mixed municipal wastes; however, few full scale recovery plants exist." One of the primary reasons which has been continuously cited is the lack of adequate markets for recovered materials. This deficiency, according to the National Center for Resource Recovery, "was felt to be partially the result of federal policies, such as tax subsidies of virgin materials and a reluctance to force internalization of the costs of environmental degradation." EPA, however, feels that "additional incentives (for recycling, other than GSA paper purchasing specifications, Defense Department procurement policies, and Treasury Department industrial revenue bonds) are not considered desirable at this time." Instead, EPA is providing technical planning assistance to the States so that the States can set up their own solid waste management plans, including privately managed resource recovery and energy conservation projects wherever feasible.

Since the Resource Recovery Act (which has already been extended one year through FY 1974) is scheduled to terminate on June 30, 1974, Congress has recently conducted hearings in an attempt to define the solid waste "problem" and develop a "workable" solution.

Of the major solid waste bills now under consideration, the Administration's bill (the "Hazardous Waste Management Act of 1973") has the most limited federal role.

The bill (H.R. 4873) would require the Administrator of EPA to identify hazardous wastes, establish treatment and disposal standards for such wastes, and establish guidelines for State programs to implement these standards.

The "Comprehensive Waste Management and Resource Recovery Act," (H.R. 13176), introduced by Congressman Rogers, would assure that State and local solid-waste management practices are designed to the maximum extent feasible to realize certain objectives of national policy.

Toward this end, the proposed legislation establishes a new Federal-State-local review system for solid waste management and resource recovery. There are five basic elements to this system: (1) general national objectives; (2) specific requirements; (3) authority for the Administrator of the Environmental Protection Agency to prescribe guidelines to effectuate the general national objectives and the specific requirements listed in the bill; (4) State waste management and resource recovery plans which must, to the maximum extent feasible, effectuate the general national objectives and must comply with specific requirements and EPA guidelines; and (5) plans developed by local government which States are to review and adopt as their own if they meet the foregoing requirements.

Congressman Tiernan and Senator Hart have also introduced companion omnibus bills (H.R. 11878 and S.2753) on solid waste management this Congress. The bills divide the legislation into major policy areas, including transportation policy, federal procurement, product standards and regulation, unsafe disposal practices, energy recovery, etc. The bills set up federal guidelines and regulations for many of the areas and require reports to Congress on freight rates and hazardous wastes.

Finally, Senator Domenici has recently introduced legislation (S. 3277) amending the Solid Waste Disposal Act. The bill is aimed primarily at encouraging full recovery of energy and materials from municipal, industrial, and other solid wastes wherever practicable by 1985, and at providing for controls over hazardous wastes. The bill also requires EPA to establish an Office of Energy and Resource Recovery to implement these objectives with maximum cooperation between Federal, State, local, and private sectors.

From the pending legislation, there seems to be general agreement for the need of a Federal regulatory program of hazardous wastes control, a program of resource recovery and energy conservation (on the Federal, State and/or local levels), a study and/or review of Federal policies which discriminate against secondary materials, and enforcement mechanisms to carry out the general purposes of these areas.

However, further analysis indicates that there is no consensus as to the specific approach which Congress should take to effectuate these policy considerations in a national solid waste management program.

Radiation is an area where more and more attention is required by Congress. Legislation to deal with one or another aspect of radiation and radioactive materials in the environment can be reasonably expected during the next several years. Much of the proposed legislation will probably relate to radiation and radioactive materials from civil use of nuclear power, however legislative attention may also turn to radiation and radioactive materials from non-nuclear sources.

Legislation dealing with measures to control and limit possible exposure of the public to radiation and radioactive materials from civil use of nuclear energy is increasingly likely to be introduced because of two trends. First, the general assumption that nuclear powerplants will increase rapidly in number and by the end of the century will supply more than half of all the electricity generated which will represent about 25 percent of the forecast annual energy input into the U.S. economy. Presently the 44 licensed nuclear power plants provide about 6 percent of U.S. electrical generating capacity. As of March 27, 1974, the situation for commercial nuclear power plants was as follows:

44	plants licensed to operate
54	plants with construction permits
105	plants on order
19	letters of intent
222	total

26,990 Megawatts electrical
52,289 Mwe
114,464 Mwe
21,440 Mwe
214,183 Mwe

The spent nuclear fuel from these plants will be the source of enormously radioactive wastes which will have to be transformed into some solid, stable form and then stored perpetually, i.e. for several centuries at least. Operation of these plants and the supporting nuclear industry will also produce quantities of low level radioactive wastes which will probably be buried. Finally, the milling of uranium and thorium ores will produce large piles of tailings which contain naturally radiative materials that give off radioactive gases radon and thoron.

The second factor is an increasingly well organized and articulate opposition to nuclear energy. Ralph Nader, for example, has now become an active opponent to nuclear power and there are proposals that future construction of nuclear powerplants should be banned or at least suspended until absolute proof is provided that catastrophic releases of radioactive wastes cannot occur in any conceivable circumstance.

Types of legislative proposals relating to radioactive materials from nuclear power can include the following.

The Atomic Energy Act presently preempts the setting of standards for routine emission of radioactive wastes from nuclear powerplants to the Atomic Energy Commission. While these quantities are small in terms of radioactive materials naturally present in the environment, some State governments have attempted to impose emissions standards more stringent than those of the AEC. Past bills to so authorize the States have not been acted upon. Similar bills can be expected.

At present it is not clear who will be responsible for building and operating the facilities for perpetual storage of high level radioactive wastes, and burial grounds for low level wastes. Four commercial burial grounds now exist, but their future may be uncertain. No facility now exists for final storage of high level wastes and proposals by the AEC to build a demonstration storage facility in Kansas a few years ago led to substantial and effective opposition from Congressman Skubitz.

A permanent storage facility will be needed because the nuclear industry can temporarily store only a limited amount of radioactive wastes. Legislation will probably be needed, either to make this storage the function of the Federal Government, or to provide special incentives for a privately financed and operated venture -- such as waiver of antitrust restrictions on an installation jointly funded by companies in the nuclear industry, tax relief, etc.; and to specify the responsibilities of the private entity.

In principle the regulation of tailings from uranium mills, and perhaps thorium mills, is the responsibility of the State governments. However current problems with such tailings at some mills indicates that the respective responsibilities of the State and Federal Government and private owners are unclear. Legislation to clarify these respective responsibilities may be necessary.

While the probabilities of a catastrophic release of large amounts of radioactive wastes from a nuclear powerplant or a fuel reprocessing plant are considered to be very small by the AEC, there is no absolute assurance that such a release can never occur regardless of circumstances. Should a large release occur, particularly near a populated area, a number of emergency measures would have to be taken to warn and advise local authorities and the public. AEC licensing procedures require the operator of a nuclear powerplant to have emergency plans, however the adequacy of these plans for actions to be taken outside the plant boundaries may be somewhat in doubt in terms of the abilities of local jurisdictions to take swift and correct measures. Legislation may be seen needed to provide technical advice and assistance and financial assistance to local jurisdictions near large nuclear facilities to keep emergency plans and key personnel ready for use. Likewise, the responsibility of the Defense Civil Preparedness Agency of the DoD and General Services Administration in its emergency preparedness role may need expansion or clarification as these relate to planning for large scale nuclear emergencies.

Bills have been introduced in the past for a temporary or permanent moratorium upon nuclear power plants because of the risks perceived by the sponsors from the possible large scale release of radioactive materials in an accident, because of the requirements for perpetual storage of high level wastes, and because of fears that nuclear materials (Uranium-235 and plutonium) might be stolen for terrorists, criminals or foreign agents. To date no hearings have been held on such proposals.

The rapidly increasing use of microwave and other electromagnetic radiations and lasers in communications and industry increases the prospects of electromagnetic pollution of the environment. At present no single Federal agency appears to have responsibility or much interest in this. The Federal Communications Commission's statutory responsibility is limited to consideration of interference between different categories of electromagnetic radiation use with little, if any, attention to public health or environmental aspects. Federal legislation is limited mainly to the Radiation Control for Health and Safety Act of 1968, P.L. 90-602, which authorizes performance standards for electronic products sold in interstate commerce that emit such radiations, but this legislation does not extend to use of such products, or to licensing of their operators. The initial thrust of regulation under this Act has been directed at dental and medical x-ray machines and at microwave ovens.

Legislation could be anticipated that would require investigation of the public health effects of an increasing presence of such radiations in the environment of the home or workplace; and to regulate their emissions.

Probably the largest source of exposure to radiation in the United States is from the use of x-ray machines in dentistry and medicine. Bills have been introduced to provide for Federal licensing of x-ray technicians. While no action has been taken in the past, it seems likely that such bills for such licensing, or to set minimum standards for State licensing, will be introduced. Such legislation could extend also to operators of powerful industrial x-ray and laser equipment.

Radioactive materials such as radium can be extracted from nature. Many others are artificially produced in nuclear reactors. A third source for artificial radioactive materials is large machines, such as cyclotrons and linear accelerators. The choice of radioactive material for a particular use in medicine, research or industry depends upon the technical qualities of the radiation desired and also upon economics of production. It seems likely that machine produced materials will increase in the future. However the responsibility for regulating these materials is vague. In principle it could belong to the States, but few states have amended their radiation control legislation to specify these manmade materials. Also it could be assigned to the Atomic Energy Commission which directly, or through the states regulates possession and use of reactor produced radioactive materials. Legislation could be anticipated to clarify and assign the regulatory responsibility.

In closing, I would just like to say one thing and that is to emphasize the good impacts that can come out of the reorganization I discussed earlier. Congress is limited in its dealing with legislation and its dealing with the administration in all the varied areas of environmental control. A committee which would have jurisdiction over all aspects of pollution, including air, water, solid wastes, etc. would be able to apply this expertise on a continuing basis and have a continuing and detailed oversight function which now is not as effective as it could be. The overall impact and effectiveness of environmental control legislation would be enhanced. I see the possible reorganization of the Congress as something very good, something that can be very effective. This would be the most important environmental legislation of this Congress.

LIMESTONE SCRUBBER SLUDGE-AN EXAMPLE OF AIR POLLUTION CONVERTED TO SOLID WASTE

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ABSTRACT

Federal air pollution legislation provides authority for regulation of emissions of sulfur oxides and authorizes the research, development and demonstration work needed to provide improved systems for its control. Exercise of the powers conferred, by the U.S. Environmental Protection Agency and predecessor organizations, has led to substantial application of lime and limestone scrubbing systems in the utility industry. These processes capture sulfur oxides and produce a sludge which has potential cross-media environmental impact. The importance of this potential impact is presently a subject of considerable controversy. This paper briefly considers events which have led to application of lime/limestone scrubbing systems and discusses the general nature of the waste disposal requirement. Sludge disposal technology is discussed and opinions relative to the overall importance of this problem are expressed.

INTRODUCTION

The Clean Air Act of 1970 and the predecessor Air Quality Act provide authority both for regulation of emissions of sulfur oxides and for Federal support of the research, development and demonstration of technology for control of emissions from industrial processes. Since the legislation was enacted many sulfur oxide control regulations have been promulgated at both the State and Federal level. The Federal authority to conduct research, development and demonstration has been used to promote development of flue gas cleaning systems for control of power plant emissions of sulfur oxides. Particular emphasis has been given to work on development of lime and limestone wet scrubbing systems which collect the sulfur and produce a calcium sulfite/sulfate sludge with potential for pollution of streams and/or underground water supplies if it is not properly disposed of.

The legislative provisions for Federal participation in development of control technology is quite broad. Authority to participate in all types of research, from bench through full scale demonstration projects is explicit. It is clear that development of environmentally sound methods for control of major air pollutants was intended. This is evidenced by the broad nature of the R&D authority which was conferred and by specific recognition of the need to consider ultimate disposal of potential pollutants. The actions of the Federal agencies in execution of their responsibility for development of sulfur oxides control systems have also reflected general recognition of the need to assure that control of air pollution does not lead to other serious environmental impacts. The approach to development of lime/limestone scrubbing systems can be analyzed to specifically illustrate this concern.

The Federal Approach

In 1967 Congress first authorized expenditure of funds for development of sulfur oxide control systems. At this time a Federal activity intended to complement work being done by industry was begun. Federal work was concentrated on non-proprietary control approaches which were felt to have widest potential applicability. Early in the program limestone scrubbing research and development was identified as an activity considered especially appropriate for Federal attention. The wide availability of limestone, the anticipated preference of utilities for a process with no by-product to market, and early activity on the part of equipment vendors to develop limestone based scrubbing systems all suggested that such processes would find substantial, industry-wide application. On the basis of this expectation work on lime and limestone systems was given highest priority.

The early Federal programs demonstrated recognition of the necessity for controlling potential environmental impacts of limestone scrubbing systems in several ways. Closed-loop operation, where no untreated scrubbing liquor would be discharged, was set up as a process requirement. It was also recognized that solid waste disposal would be a significant economic factor and some work was undertaken to identify possible uses for sludge; for routine sludge disposal no work was undertaken on development and demonstration of methods. It was felt that methods that were technically and economically feasibly for other large scale, high volume disposal operations would be adaptable to limestone scrubber sludge. This assumption, made in the late 1960s, still appears to be basically sound but increasing sensitivity to all possible environmental impacts, coupled with increased awareness of the importance of sludge disposal technology as a factor in acceptance of flue gas desulfurization systems has lead to a closer examination of all disposal options by both government and industry groups. At present evaluation and optimization of environmentally sound approaches to scrubber waste disposal is one of the immediate objectives of a substantial national program.

The Nature of the Problem

The chemistry of lime and limestone scrubbing is now understood well enough to permit fairly accurate estimates of the amount and general character of sludge that will be produced when lime or limestone scrubbing is used. It was reported in a recent study of sludge disposal options in the State of Ohio that a "typical" Ohio power plant burning 3.3% sulfur coal with 12% ash and utilizing a limestone scrubbing system would produce almost 1½ million tons per year of waste composed basically of $CaSO_3/CaSO_4$ sludge containing some unreacted $CaCO_3$, fly ash, and water.[1] For lime scrubbing the amount would be slightly less. The solid waste produced by a plant with limestone scrubbing is about three times what it would be for the same plant without SO_2 collection.

This quantity of material represents a substantial disposal problem but the amounts are not extraordinarily large when compared to other solid wastes which are now being handled. This can be illustrated by considering Table 1 which shows data from the Ohio study. This report shows the amount of solid waste which would be produced if 85% of the Ohio power plants which are expected to be operating in 1978 were equipped with limestone scrubbing. The amount of solid and the like. Ponds lined to prevent leaching and eliminate overflow, various dewatering methods, chemical fixation, and other related technology appears to be potentially applicable.

Development and Demonstration of Sludge Disposal Methods

The three approaches which are being used or considered for disposal of limestone scrubber sludge include 1)ponding,in well designed facilities, 2)treatment to dewater or stabilize the sludge prior to ponding or landfilling and 3)processing of sludge to produce lightweight aggregate or some other useful product. At present prospects for utilization of large quantities of sludge are not considered good. Ponding and landfill are expected to find widest usage in the near future. It has been reported that 60% of the existing or planned U.S. installations will employ ponding, the balance are planning for treatment and landfill. Ponding is the least desirable solution from the standpoint that it renders land unusable until it is reclaimed. It appears however to be a fairly well developed art which would be adaptable to present problems. Treatment to reduce volume and increase stability will increase land use efficiency but may be too expensive to be economically attractive in some situations.

The possible water pollution sources from either ponding or landfill operations are run-off water or leachate which may contain soluble toxic species, excess levels of sulfate or chloride, excessive dissolved or suspended solids, or excessive chemical oxygen demand. It has not been established whether any of the above potential problems represent serious threats. It seems clear however that leaching and run-off must be prevented to assure that ground water or stream pollution does not occur.

Numerous methods for disposal of scrubber waste in economic, nonpolluting ways are receiving attention. Techniques for dewatering are being investigated to evaluate their effectiveness in reducing the percentage of water in the sludge below the 50% which is typical of material which has been allowed to settle in a pond. Thickeners, filters and centrifuges are being considered for this application. Also systems for oxidation of sulfite to sulfate are being studied as a means for improving the settling and handling characteristics of sludge. In addition chemical and physical characteristics of the sludge itself are being studied in some detail to provide better data for design of suitable ponding systems and provide information which will be useful in development of improved processes for further treatment or conversion of sludge.

Other work is underway to develop and demonstrate various "fixation" processes which would convert the sludge to stable landfill material and methods for conversion of the sludge to lightweight aggregate for use in construction, as stabilized road bed material, and related uses are being evaluated.

The extent of this work is described in a report presented in the past year that indicated that some 13 utilities were either actively engaged in sludge disposal or were planning or developing disposal systems. In addition at least four companies were said to be engaged in work to develop or demonstrate chemical fixation processes and work to find ways to utilize sludge was underway in several other organizations. This is all in addition to a significant amount of federally supported work.

The cost for utilization of any of the disposal methods still appears to be uncertain. Estimates have been reported to vary from \$5,000/acre to \$30,000/acre for ponding. (1) For a 1,000 mw plant waste from other sources is shown for comparison purposes. It can be seen that the amounts of sludge would be modest by comparison with the waste from phosphate fertilizer production even when the unrealistically high percentage of 85% control is assumed. This seems especially significant when it is considered that 80% of the phosphate fertilizer waste is generated in Florida and that much of the total for the state is concentrated in a relatively small area.

Even on a national basis projections for sludge disposal rates do not seem excessive in comparison with other sources of waste. At present about 10,000 mw of the generating capacity in the U.S. has been equipped with lime or limestone scrubbing. Forecasts for rate of increase in the nationwide usage of all flue gas cleaning vary widely but they average in the neighborhood of 100,000 mw by 1980. Using the same assumptions with respect to sulfur content, plant load factor etc., which were used for the Ohio estimate and assuming that 75% of flue gas cleaning is limestone scrubbing the calculated national sludge production rate for 1980 would come to about 150,000,000 tons per year (75,000,000 t/yr dry basis). This would be a modest increase in the total national solid waste output which amounts to billions of tons per year for mining alone. From this it would appear, that the quantity of material to be dealt with will not be unreasonable and will in fact be small compared with solid waste which is produced by some other industries.

Quantity of material obviously is not the only consideration. Potential problems which may be associated with the unique chemical and physical characteristics of sludge must be weighed. The exact character of sludges will vary with many factors associated with type of scrubbing (lime or limestone), composition of coal and limestone reactant, and other factors that will be peculiar to a given site. It is possible to generalize to some degree however and the "typical" sludge composition as defined by the previously discussed Ohio study is as follows:

50% Solids, 50% Water
Solids Composition
$CaSO_3 \frac{1}{2} H_2O$-36%
$CaSO_4 2H_2O$-4%
$CaCO_3$-12%
Fly Ash-48%
Trace Elements

There has been some speculation that toxic species originating in the limestone or fly ash may contaminate surface or underground water if improper disposal methods are used. Also sludges from some systems have been reported difficult to handle because of low density problems attributed to high $CaSO_3$ content. There is however no information to show that limestone scrubber waste could not be processed using methods applicable to processing of other solid wastes such as power plant fly ash, sludge from treatment of acid mine drainage, municipal refuse, gypsum slimes and gypsum sludges from phosphate fertilizer production, coal processing refuse, waste from extraction of metals (ferrous and non-ferrous)

TABLE I. COMPARISON OF MAJOR SOLID WASTE DISPOSAL PROBLEMS

Waste Material	Quantity Disposed of Annually (Metric Tons)
Phosphate Rock Slime from Fertilizer Mfgr	36,000,000 (1967) 4-6% solids
Gypsum from Fertilizer Mfgr	25,000,000 (1973) 85-90% solids
Fly Ash from Power Generation	9,400,000 (1978) 80% solids
Scrubber Sludge from 85% of Ohio Power Plants (Fly ash not included)	15,000,000 (1978) 50% solids

For a 1,000 mw plant 1,100 acres have been estimated necessary for sludge generated over 20 years. (2) The cost per ton of wet sludge assuming $20,000 per acre comes to about $.70/ton dry basis). The cost of chemical fixation of sludge has been estimated at about $2.50 per ton (dry basis) exclusive of hauling cost by one company offering a system. (1) Another company which is evaluating chemical fixation of sludge from their scrubbing reports total disposal cost of about $17/ton (dry basis) including hauling. It seems reasonable to suppose that the cost will normally fall somewhere between these two extremes. Also it is interesting to note even at $10.00 per ton (dry basis) that the operating cost for sludge disposal will be in the neighborhood of .4 to .8 mils/Kwh for plants with a reasonably long remaining life and a relatively high load factor. This would be an important operating cost amounting to something like 20-40% of the total annualized cost for scrubbing; And this amount is significant when compared to the 10mils/Kwh which power might cost if produced without flue gas cleaning. At this cost for sludge disposal limestone scrubbing might not be competitive with other sulfur oxide control options. On the other hand incremental costs of this magnitude would not make the process economically impractical where control was important and other remedies are not readily available. Limestone scrubbing will likely be a least-cost solution in some situaions and in others may be the only practical means for SO_x control.

SUMMARY

In summary it would appear that limestone scrubber sludges will present a new waste management problem of some importance. It has not been shown however that it will be any more difficult to handle than other solid waste problems which are similar in magnitude and of a similar nature. It does not appear that development of basically new technology will be needed. Rather, it seems to be a situation where existing technology should be applied to optimize land usage and insure against water pollution.

Limestone scrubbing technology was developed pursuant to legislation which appears to give adequate recognition to control of cross-media impacts. The agency mainly responsible for demonstration of the technology has taken reasonable actions to assure that it has overall environmental acceptability.

In conclusion it appears that the general approaches which led to development of limestone based scrubbing systems were sound and it seems that the process itself will prove to be a useful tool.

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CROSS-MEDIA IMPACTS WITH SOLID WASTES

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Compensation for interrelated, overlapping and occasionally opposing environmental control requirements assure that coordination policies must be developed which maximize program efforts and limit interagency impacts. As an example solid waste has evolved as "The Third Pollution" next to water pollution and air pollution with sufficient impact to assure increases in total solid wastes for each increment of decrease achieved in water and air control programs. The need for standardization and consolidation of program goals, rules, regulations, policy developments and enforcement activities between State agencies, interstate agencies and Federal programs is detailed. Each new level of environmental control established on the State or Federal level results in new barriers to existing control programs. The constraints brought about in this manner can best be minimized through uniform program development efforts designed to lessen impacts.

The importance of solid waste as "The Third Pollution" evolved slowly in this country over the last fifty years and it was only in the last ten years that the need for establishing uniform solid waste control programs in this country was recognized.

In the development of new programs such as this there occurs many instances where existing and proposed regulations interface and often times overlap. Any thorough discussion of air quality, water quality or solid waste control program effectiveness must of necessity involve consideration of the interrelationships, the overlaps and the interfaces of one program with the other resulting in numerous inter, intra and extra agency policies, agreements, understandings and formalized review and approval procedures. This type of discussion would also, of essence, require the disclosure of effects on the general environment surrounding, the effects on commerce in the area, traffic patterns, effects on land use past, present and future, the sociological effects, health effects, energy crisis and various and sundry side-effects not the least of which include the effects on hunting and fishing in the area and for a radial distance of at least ten miles.

No program, of the nature of a solid waste management program, would be effectively established and implemented today if it were not for the urgent overpowering need for such a control program.

As the concern is broadened for righting the wrongs man has brought about in his environment the need for more stringent standards and procedures for control of air emissions is advanced and the necessity to further treat and polish the effluents from waste water carriage systems becomes manifest. With each air quality standard revision and with additional water quality standard applied there occurs concurrently an increase in the quantity of solid waste and generally a reduction in quality of the solid waste to be managed. That is to say more solid waste of an increased level of hazard has to be managed, processed and disposed.

At the same time methods of disposing of solids interrelate with control programs for air and water quality. Land disposal methods for solids which presently accounts for a full 90% of the solid waste generated in Pennsylvania, has a basic and significant impact on water quality. Incineration and energy and resource recovery approaches to solid waste management, such as pyrolysis and refuse as fuel purposes, result in added impacts on air quality control programs.

The concept of land use planning which is rapidly evolving today will place new limitations on existing control of programs, and set restrictions which will require major modification of current environmental control programs. An example already seen in Pennsylvania is the thrust to exempt prime agricultural land from such uses as sanitary landfill as exemplified in Pennsylvania House Bill No. 1234, and a recent Commonwealth court decision on constitutional amendments gives high priority to the conservation of our natural, scenic, aesthetic and historical resources.

The move toward resource recovery of solids seems to be stimulating a headlong jump into capital intensive projects which utilize technology which has barely been defined let alone fully tested or evaluated.

The evolvement of the green revolution is resulting in a wide scale assertion that incineration solely for the purpose of refuse volume reduction is wasteful and that sanitary landfill is the least desirable method of coping with the nation's ever-growing volumes of waste. Ironic that the method which is least desirable can be costed out to be the least expensive and most controllable environmentally. Today public sentiment seems to grasp for the undeveloped technology of resource recovery and recycling and energy recovery. Little careful consideration has been given to the adverse environmental impacts which may result from the undeveloped technologies which we are expected to apply. This is said not to minimize the importance of resource recovery projects or approaches but to point out the need to improve the methods of land disposal of solid waste to the end of minimizing adverse environmental impact. Since no matter how much solid waste may be reduced via resource recovery approaches in the future the urgent overpowering need for land disposal will always be present. In fact, one thing is evident, should the technology prove satisfactory the bulk of the materials pulled off stream would be those of a non-hazardous nature and the remainder would be hazardous to a large percent, which ultimately would require improved disposal methods and more coordination with other environment related control programs. Already the Federal Environmental Protection Agency is promoting the passage of Senator Baker's Senate Bill No. 1086 entitled "Hazardous Waste Management Act of 1973" which would set up Federally controlled and operated solid waste disposal sites.

Paramount to all of the aforementioned approaches is the need for interagency understanding, cooperation and consideration. There exists, quite often, interrelated, overlapping and sometimes opposing requirements which one official agency places upon another as a result of existing laws. As an example a municipal sewage treatment facility which is to be constructed affects the responsibilities of the Air Quality Control Program, Solid Waste Management Program and the Water Quality Management Program. At present, in Pennsylvania a coordination policy has been established wherein the procedure for review and approval for such a permit is coordinated by the Department of Environmental Resources to allow for a maximum of efficiency, a minimum of review time and a limited interagency impact to the applicant. Upon receipt of a permit for the treatment plant the applicant possesses a functional waste water treatment facility, with an incinerator for sludge processing and a suitable site for disposal of remaining solids and ash residue.

In setting up a solid waste disposal site,e.g., a sanitary landfill many considerations must be made by the applicant. The proposed site must first conform with the existing solid waste management plan established for the area or region served by the proposed site. Requirements for highway access must be met through consultation with the Department of Transportation. The zoning requirements of the town, township and county must be considered. The fears and objections expressed by neighboring residents must be dissipated. The Labor and Industry Department requirements for safety must be met. The local municipal building codes must be adhered to. The legal ramifications must be met concerning title transfers and lease arrangements. All of these things must have been considered by the applicant before applying for our permit.

Once the permit is applied for, then there is an interaction between Geologists, Soil Scientists, Aquatic Biologists, Engineers, Environmental Protection Specialists, Solid Waste Specialists and Sanitary Engineers. The interaction here assures that standards of air, water quality and solid waste management are met with necessary provisions to prevent future problems from occurring. The Clean Streams Law, The Air Quality Standards, and The Solid Waste Management Act are applied and all requirements are met. Then and only then is a permit issued. Somewhere within this complicated sounding procedure there must be an understanding reached between each agency and the applicant. In all cases there will be some interrelated, overlapping and, occasionally, some opposing requirements which are placed by one official agency upon the requirements already mandated by law to another. Also, gaps occur where existing controls do not cover certain aspects of an environmental problem. For all of these reasons, new laws, new controls, and new concerns become necessary.

As regulatory solid waste responsibilities increase more types of waste are given more specific attention thereby increasing the maze and complexity of bureaucratic "red tape" in the communication process so disliked by those affected. Control of coal refuse wastes from coal mining operations in Pennsylvania is a good example:

Pennsylvania Deep Bituminous and Anthracite Mines produced 82,000,000 tons of coal in 1972 with 30% waste (24,600,000 tons). Bituminous and Anthracite Mining Acts passed to control mining activities.

Early 1960's Air Pollution Commission Regulation I passed to deal with air pollution problems.

1965 Clean Streams Act passed to deal with water pollution problems.

1967 Bond Issue passed $500 million to extinguish and prevent fires, control acid mine drainage, refill and reclaim mines and prevent subsidence.

1968 - As result of tragedies Coal Refuse Act passed. Primarily concerned with stability.

1968 - Solid Waste Management Act passed. Prior to 1971 responsibility divided between Department of Health, Sanitary Water Board, Department of Mines and Mineral Industries.

1971 - New Department of Environmental Resources created which combined administration of laws under one Department.

Survey of 135 active coal piles with 93 contributing to air, water and safety problems. Also, an estimated 1200 abandoned coal piles exist.

1973 - Environmental Quality Board adopted new Coal Refuse Regulations pursuant to the Coal Refuse Act. Its purpose is to prevent general environmental problems, require restoration and show proof of financial responsibility.

Today, more than ever before, the need for standardization and consolidation of program goals, rules, regulations, policy development and enforcement activities is obvious. Actions should be taken to bring about uniform program development thus assuring only minimal conflict between requirements of one control agency over those of another. All this without a consequent loss in environmental quality. Although the statement is relatively easy to make, the follow-through to action appears more difficult with each added level of environmental control.

The Federal Water Pollution Control Act was welcomed by me when it was shown to provide some monies for solids controls. Yet it appears to have set up a barrier between the Solid Waste Management Program and the benefits to be derived from this Federally sponsored Act. It appears obvious that the Federal Hazardous Waste Act, once enacted, will set up similar constraints.

An understanding of the cross media program responsibilities established by new legislation can be obtained by looking at the key provisions of the Federal Hazardous Waste Management Act which calls for Federal authority to regulate the treatment and disposal of hazardous wastes. These provisions include:

1. Authority to designate wastes as hazardous by EPA.
2. Authority to regulate treatment/disposal of selected waste categories by the Federal Government at the discretion of EPA.
3. Authority for setting of Federal treatment/disposal standards for designated waste categories.
4. State implementation of the regulatory program subject to Federal Standards in most cases.
5. Authority for coordination and conduct of research, surveys, development and public education.

Since the purpose of the proposed Act is to overcome inadequacies in existing laws to provide controls over hazardous waste management practices it appears necessary to increase the effectiveness of The Clean Air Act of 1970 and the Federal Water Pollution Control Act of 1972. The legislative authorities available for the control of hazardous waste deposition on land are not sufficient to result in properly controlled disposal to prevent the consequent migration of such wastes into the air, water and land media.

All that can be done is to weigh the benefits derived against the limitations established and to strive to minimize the impacts.

POLLUTION ABATEMENT RESULTING IN CROSS MEDIA IMPACTS: RADIATION

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As Mr. Spaet indicated earlier, the objectives in presentations this afternoon are for the speakers to examine ways in which the implementation of the national legislation related to the control of the pollutants, the particular type of pollution with which the speaker is concerned, will result in negative impacts on water quality and/or create the need for water pollution control technology. The fact of the matter is that the nature and implementation of the legislation dealing with the control of radiation and radioactivity as a potential environmental pollutant is unique for two basic reasons. One, because it is not limited to the protection of any one environmental medium but encompasses all aspects of the protection of man and his environment from the potential hazards associated with radioactivity. This aspect is not entirely unique because pesticide and solid waste legislation is not media-oriented but pollutant-oriented. Secondly, the legislation dealing with control of radioactivity is not only related to controlling the impact of potential pollutants on the environment but is concerned with the control and regulation of the development and utilization of the entire technology which is the source of the potential pollutant. This makes it unique in comparison with all other forms of environmental protection legislation.

The national legislation dealing with the protection of man and his environment from radiation hazards, i.e., the Atomic Energy Act of 1954, as amended, differs substantially from the development and implementation of other environmental protection legislation in three very important ways. I regret that in the time allotted I can only illustrate the very major differences that exist in the development and implementation of this legislation but I think they will serve to make the basic points I had in mind.

You may recall that the atomic energy program was conceived during the war as a Manhattan Engineering District project which was solely oriented toward the development of an atomic weapon. The concept of developing peaceful uses of atomic energy was not fully implemented until 1946 when the Atomic Energy Commission was created and part of its mission, in addition to continuing the development of the weapons technology, was to seek to develop peaceful uses of atomic energy.

Unlike the Federal Water Pollution Control Act, the Clean Air Act, and other environmental protection legislation, the Atomic Energy Act was not developed as remedial legislation designed to correct and improve an environmental pollution problem that had already developed as a national problem. It was, in fact, a very comprehensive piece of legislation, deliberated over a very long period of time, designed to authorize and provide for Federal control of the development of a new technology, the peaceful uses of atomic energy, at its very inception before a public safety or environmental hazard was allowed to develop. This evolutionary process accounts for two of the major differences between the Atomic Energy Act and the other specific pollution control and environmental protection legislation. First, the Act required that protection of the health and safety of the public be an integral part of the development, utilization, and control of the peaceful uses of atomic energy. It must be remembered that deliberation of the Atomic Energy Act was conducted in a national and public atmosphere that was still very newly impressed with the awesome consequences of the use of atomic weapons so that protection of the public health and safety was incorporated as a paramount consideration in the development of the legislative requirements for the control and regulation of the development of peaceful uses. It must also be remembered that, at that time, there were no public or political pressures to proceed posthaste with the development of peaceful uses of atomic energy. It was conceived of as a potential resource but, unlike the environmental movement, there were no emotional pressures generating tremendous political pressures on Congress and the Administration to proceed hastily with the development effort. Secondly, the Act, did not only provide for the control and regulation of the effluents or their environmental effects but it provided for the control and regulation of the entire technology including research and development, site selection, design, construction, and operation of atomic energy facilities, and for regulation of the possession and use of the related radioactive materials. I know of no other technology or industrial development that is so completely regulated, "from the cradle to the grave," in such a comprehensive fashion.

The third important difference between the Atomic Energy Act and other environmental protection legislation is that the Act was not concerned with the protection of a particular environmental medium, such as air or water, but required the protection of man and his environment from all potential radiological hazards both in his working environment and in the environment outside the facility. It included not only concern for the release of radioactive materials in the form of contaminated airborne or waterborne effluent streams but the problems associated with direct radiation, a somewhat unique property of this pollutant. It also was concerned with protecting land, food stuffs, and all environmental media as well as such aspects as regulation of the transportation of the material so that it would not become an environmental problem.

The Atomic Energy Act and its implementation also provided for the conduct of the necessary research and development to study the effects of radiation on man and his environment. Over the years such extensive and substantial research has been done that radiation is generally acknowledged by many as being the most thoroughly studied and best understood of the potential industrial and environmental hazards with which man is confronted. I want to emphasize that I don't mean to imply that all the answers are in hand. I am saying that in the field of radiation protection, extensive research has been conducted on biological effects, genetic effects, and environmental impacts, which are now only beginning to be considered in connection with other types of pollutants.

The atomic energy program also provided for the development of the necessary technology for the measurement, evaluation, and control of radiological hazards and the development of the technology, essentially a completely new technology, for the treatment, disposal and storage of the unique kinds of waste generated in the application of atomic energy to peaceful uses so there was a related waste disposal and waste treatment technology evolving as the development of the peaceful uses was proceeding. As a result of this concept of overall control and regulation of the development and use of the entire technology, there are, in fact, no negative cross-media impacts associated with environmental radiation and radioactivity which are not or should not be factored into the development of the technology. Again, I want to emphasize that all the problems are not solved. In fact a good deal of the mechansim for attacking them is included in the legislation that provides for the development, control, and regulation of atomic energy. There will be many who will argue that the job is not being done well enough and there are other aspects that warrant consideration. The fact of the matter is that, as a result of the national regulatory process, the development of the peaceful uses of atomic energy is conducted in more of a goldfish bowl atmosphere than the development of any other technology, through public review of regulations and public hearing processes as well as the adversary proceedings that are a sign of the times. The impact of radioactivity and radiation on all environmental media including some not considered in connection with other types of environmental pollutants are incorporated in any evaluation of the environmental effects of radioactivity.

In summary, whereas in other environmental protection legislation, one form of media is being considered without the commensurate concern for the impact of stresses imposed on other media, the nature of the atomic energy legislation deals with the total technology and the total concept of control and regulation. It deals not only with all media but with all sources of environmental impact and with regulating the entire developing technology.

IMPACTS AND CONSEQUENCES OF EXISTING HAZARDOUS WASTE MANAGEMENT LEGISLATION

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ABSTRACT

The control and proper disposal of the over 10 million tons of hazardous wastes generated annually by United States industry has the potential of eliminating the non-point source water pollution traceable to such wastes. The proposed Hazardous Waste Management Act and similar legislation will cause the concentration and disposal of the wastes to specific land sites which will be selected, designed, constructed, and monitored to ensure perpetual isolation of the wastes from the environment. Experience with improper land disposal provides many examples of contamination of surface and ground waters, a condition which must be avoided. Accordingly, methodology for site selection, technology for hazardous waste stabilization and site containment, and techniques for monitoring, halting and reversing accidental contamination of surface or subsurface waters must be developed to assure the ultimate effectiveness of not only hazardous waste legislation but also of air and water pollution legislation.

INTRODUCTION

Discussion of the impacts and consequences of existing hazardous waste management legislation requires, first, a definition for the term "hazardous waste", and, second, a conceptual expansion of the word "existing" to include both enacted and pending legislation. The accepted current definition of "hazardous waste" is "any waste or combination of wastes which pose a substantial present or potential hazard to human health or living organisms because such wastes are lethal, nondegradable, persistent in nature, biologically magnified or otherwise cause or tend to cause detrimental cumulative effects" (1). This definition, while not precise, does present a framework against which a particular waste might be classified as hazardous. Enacted federal legislation applicable to hazardous waste management is embodied primarily in water pollution laws although specific legislation is under consideration. In the following the limitations of the present legislation will be discussed briefly. The need for comprehensive hazardous waste management legislation will be illustrated and some proposed legislation will be discussed. Finally, the technological implications of the proposed legislation will be described.

TEXT

Current control over hazardous waste management at the federal level is provided primarily through the Federal Water Pollution Control Act (FWPCA), as amended. The Federal Water Pollution Control Act is designed specifically to protect streams, lakes, coastal waters, and underground aquifers by providing limits on the quantities and concentrations of various pollutants that may be released to them by an industrial facility. Those facilities which store or treat hazardous wastes are required by FWPCA to properly treat processing effluents and any effluents from storage area drains. When hazardous waste management activities result in non-point source discharge, however, no control is provided by FWPCA. Since a major technique commonly utilized for the disposal of hazardous wastes, landfill, provides a non-point source of water pollution, the effectiveness of FWPCA for limiting environmental pollution caused by hazardous waste is seriously impaired.

The necessity for controlling the treatment and disposal of hazardous waste has been established through a number of incidents of environmental contamination traceable to improper waste management. Landfills and treatment lagoons are often the villians in such incidents. For example, a burial 30 years ago of arsenic compounds on agricultural land in Minnesota recently caused the hospitalization of several persons who drank water from a well located near the burial site. Arsenic compounds apparently had leached into the aquifer supplying the well. In 1972 an Iowa chemical manufacturing firm attempted to open burn the insecticide, phosdrin, grossly contaminating the plant area. Approximately a ton of pesticide had to be neutralized and taken to a commercial hazardous waste disposal site. In June of 1967 a dike containing an alkaline waste lagoon in Virginia collapsed and released approximately 400 acre-feet of alkaline fly ash waste. The slug of contaminant killed over 206,000 fish in the Clinch River and Norris Lake.

Attention given to the disposal of chemicals by ocean dumping resulted in Congressional hearings which focused interest on the entire field of hazardous waste disposal. The lack of definition of what constitutes hazardous wastes and the lack of knowledge of the effects of treatment and disposal practices of hazardous wastes were both indicated in the hearings. The Congress in Section 212 of the Resource Recovery Act of 1970 directed the EPA to prepare a comprehensive report to Congress on storage and disposal of hazardous wastes which would include: (1) a list of hazardous waste materials, (2) current methods for disposal of such wastes, (3) recommended methods of reduction, neutralization, recovery, or disposal of such materials, (4) an inventory of possible sites for a National Disposal Site System, (5) an estimate of the cost of developing and maintaining such a system, and (6) other information as appropriate. As a result of this direction the requested information base was synthesized for the use of both industrial and governmental waste generators and managers.

The information base generated to support the Report to Congress (1) defined both the requirement for and the practicality of comprehensive hazardous waste management legislation. Consequently the Environmental Protection Agency drafted proposed legislation which was subsequently introduced to Congress as the Hazardous Waste Management Act. The Hazardous Waste Management Act and other similar proposed legislation are formulated to assure environmental protection through the control of the storage, treatment, and disposal of hazardous wastes. It is expected that hazardous wastes will be controlled from the time they are generated to the time they are disposed of in an adequate manner. The major features of this legislation are: (1) wastes will be classified with respect to their potential hazards, (2) methods and/or standards of performance will be specifically prescribed for management of most wastes, and (3) control and enforcement methodology will parallel that used for the air and water pollution regulations.

Since the quantity and concentration of hazardous wastes will increase due to the stricter air and water pollution regulations now in effect it is particularly important that such legislation be enacted. Although proper and appropriate technology for the adequate disposal of most hazardous waste is available, often it is far more expensive than the technology currently utilized. Even if proper treatment is not expensive it may not be applied due to lack of legal requirement.

Adequate treatment and disposal methodology and technology for managing many hazardous wastes require further development. For example, methods for stabilizing wastes so that they may be safely landfilled are commercially available for application to some wastes and under development for others. Special disposal sites may have to be developed to provide for perpetual care of wastes which cannot be sufficiently stabilized. The Report to Congress located a number of sites which might be utilized for this purpose. To ensure the adequacy of such special disposal sites, techniques for site monitoring must be developed. Also the behavior of landfills must be better understood before assigning wastes to find disposal by this technique. Industry and government can both help the hazardous waste situation by developing manufacturing processes which do not produce hazardous wastes.

The ultimate effectiveness of air and water legislation is dependent on assuring that the resulting pollutant residues do not contaminate the environment. To provide the necessary assurance, legislation must be enacted to require the management of such hazardous wastes.

(1) Report to Congress on Hazardous Waste Disposal. U.S. Environmental Protection Agency, June 30, 1973.

IMPACTS AND CONSEQUENCES OF EXISTING LEGISLATION ON WATER POLLUTION CONTROL

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Thank you Jim, Ladies and Gentlemen.

When one speaks of legislation in the field of water pollution control, there is one act which stands out above all others, the Federal Water Pollution Control Act of 1972 known as Public Law 92-500 (PL92-500). This is a landmark piece of legislation, the most important act ever passed by Congress in the field of water pollution control.

I will speak as an industrialist in discussing this legislation and its impacts and consequences.

Representing the views of industry towards the impacts and consequences of the Federal Water Pollution Control Act of 1972 is a pretty tall order. As a matter of fact, it might well be an impossible task for anyone representing a divergent group such as industry to present a consensus point of view. In the first place, the Act is a highly complex document which was evolved over a period of 18 months of hearings, witnesses, and statements. Including input from industrial trade associations as well as technical and professional societies. Many disciplines participated in the framing of the Act which included engineering, biology, sociology, economics, etc. And, of course, lay citizens groups were involved in the framing of the Act. The Act covers 100 pages of meaty print. Because so many different points of view have been incorporated into the Act, I doubt that everyone in industry agrees with every provision of the document. But I do believe that most of my fellow industrial representatives applaud the intent of the Act and agree with many of its provisions. I personally believe that, by and large, in spite of its faults, the Act is a good one. If properly administered by EPA and if amended as necessary to reflect the cold facts brought out by experience, the Act will achieve the nation's goals of clean streams at reasonable costs in reasonable time frames.

Before going further, I want to make this point. The Act is now on the books. It is a law of the land. The debating is over and now is the time to get the job done right. I think the objective of all sectors of American society, including industry, is to see to it that the Act works in the most effective and the most expeditious manner possible. Also, since we Americans are now realizing that our natural resources and our finances are no longer limitless, we must do this at acceptable costs. My intent, therefore, is to offer constructive comments from an industrial viewpoint on how to make the Act work better to achieve our goals of clean streams. I intend to also touch on needed amendments to make the Act more realistic.

Let me briefly set the stage by discussing the situation in the U.S. prior to enactment of this legislation.

First of all, during the 50's and 60's the U.S. approached the problem of environmental control rather slowly and hesitatingly but also logically and rationally. This approach was pretty much formalized in the Water Quality Act of 1965. The Water Quality Act of 1965, the predecessor of the present act which I will discuss later, was really an idealistic act which, if everything else were also idealistic, would have worked beautifully. The philosophy of this Act was quite simple. All streams have a given assimilative, or self-purification capacity to absorb, dilute, and destroy wastes without any adverse effects on the stream water quality. Therefore, all wastes were to be treated to the extent that the remaining residual wastes could be assimilated by the stream without adverse effect on the water quality of the receiving streams. Under the 1965 Act, water quality standards were established for all interstate streams. The entire emphasis under the old water quality act was on the assimilative capacity of the stream. In a sense, the assimilative capacity of a stream was viewed as a replenishable natural resource to be utilized in the interests of economy.

This ideal engineering approach for many reasons just didn't work. First of all, the bill didn't have enough enforcement teeth in it. Secondly, the process of calculating the assimilative or purification capacity of a stream is not the easiest mathematical procedure. Furthermore, although it sounds simple in concept there are administrative and enforcement challenges to allocating the assimilative capacity of the stream to the various waste discharges. The States just did not have the manpower and expertise to carry out this complex task.

For these reasons, an entirely new approach or philosophy was adopted in the recently enacted legislation, the Federal Water Pollution Control Act of 1972, known as Public Law 92-500 (PL92-500). This Act placed its emphasis entirely on effluent or treatment standards. All wastes are to be treated to the same extent regardless of the assimilative capacity of the stream. Uniform and very high standards of treatment for all wastes are called for in the Act regardless of the needs of the receiving streams. Admittedly, administration and enforcement procedures are made easy by this seemingly simplistic approach. Therefore, this Act is truly a landmark piece of legislation and a radical departure from the past.

If this controversial Act is implemented as written without amendments, it will cost the Nation hundreds of billions of dollars in the next decade.

Now let's take a look at the main features of the Act. As I noted previously, fundamentally the Act makes a radical departure from the concept of using to the maximum extent possible the assimilative capacity of the stream. This precious characteristic of streams, replenishable and valuable, is ignored and not used. Stream water quality standards are not the guiding criteria. Rather, effluent standards are established and the waste must be treated to a standard effluent. The waste discharged to the Mighty but Muddy Mississippi must be treated to the same extent as a discharge to Mill Creek, or to the Fenholloway River, or to any other small creek in the U.S.A. The emphasis is on effluent or treatment standards. The only thing that can be said in favor of this concept is the ease with which it can be administered and enforced.

Let's examine the provisions themselves:

1. The Act requires that by 1977 all industrial wastes discharged directly to receiving bodies of water shall be treated with "the best practical control technology". This is somewhat equivalent to secondary or biological treatment or about 90% BOD and suspended solids removal. This applies to municipal sewage also. The United States Environmental Protection Agency (EPA) has been in the process of developing the effluent guidelines for various generic such as paper, steel, etc industries defining "best practical control technology". These effluent guidelines vary from industry to industry. Philosophically, this is an acceptable goal. All wastes from an ethical standpoint should receive some treatment. Furthermore, the technology for this degree of treatment is generally available and at acceptable costs. The catch is to define best practical control technology.

2. By 1983 the best available control technology must be applied to all industrial wastes discharging directly to receiving bodies of water. Generally, this degree of treatment is much greater than classical secondary (biological) treatment and ranges between 95 and 99% removal depending on the industry. EPA is also developing definitions of best available control technology for the various generic industries. I want to emphasize again that 95 to 99% waste removal or best available control technology is required by 1983 regardless of cost and energy requirements even if the quality of the receiving stream is so good as to not require such high degrees of treatment.

This requirement, which could cost the nation hundreds of billions of dollars, should be scrutinized by our policymakers. To require best available control technology costing billions without a proportional improvement in water quality is wasteful. Best available control technology should be applied only to meet water quality standards for substandard streams and only for those streams of some social, recreational, or economic value. To apply best available control technology to up-grade a tiny stream running dry much of the season and which offers no recreational or social value to the local region is misusing our valuable money and resources.

Application of best available control technology is certainly desirable in many cases but such high degrees of treatment should be applied judiciously and not to every discharge in the U.S.A. The technology exists to obtain 95 to 99% removals. The cost of the technology, thanks to work being done by the USEPA at the Taft Center in Cincinnati and consultants such as Battelle, is coming down. But it is still expensive and should be applied only when needed.

3. Now let's get to the real bomb of the entire Act. This bomb is called the zero discharge clause. PL92-500 calls for a national goal of complete eliminations of all pollutional loads to streams of the U.S.A. by 1985. It means all of the wastes from all of our industrial plants must be dried up by 1985. Zero means zero! And this goes even for domestic wastes. Obviously this objective of zero discharges is technically and economically impractical as well as absolutely unnecessary for the environment. Remember, air and water do have an assimilative capacity and can absorb some waste. But the concept of eliminating all pollution has considerable appeal to well meaning but uninformed citizens.

I would like to discuss further this controversial concept of zero discharge which is mentioned in the Act. Zero discharge is set up as an idealistic goal which should be achieved. Actually, I feel that zero discharge would be detrimental to the environment, rather than helpful. To require zero discharge of waste to receiving streams is putting blinders on oneself so that all one sees is the receiving stream and not see the total environment consisting of the air and the land. Zero discharge of wastes to receiving bodies of water ignores the optimum or total impact of certain operations on the overall environment. The old law of conservation of matter states that if one removes something from a waste discharge, it has to go somewhere else. If it is incinerated, the products of combustion go up and could be an air pollutant. If it is hauled to a landfill area, it is a land pollutant and could leach out and pollute ground water and surface waters. Also in incinerating the wastes, which one might otherwise discharge into a receiving stream with no adverse effect on the water quality, one is using up some form of energy, such as fuel, which is a non-replenishable natural resource. I do not have to tell you about the so-called fuel crisis going on.

Therefore, any approach to pollution control must consider the optimum effect on the entire environment -- land, air and water. Zero discharge ignores this concept and states that we should protect the water 100 percent and the land and air be damned. Putting on my conservationist's hat for one moment, and I am a long-time member of the Sierra Club and the Colorado Mountain Club, I see no logic in zero discharge since such a goal can adversely affect land, air and energy resources. As an industrialist, all I see in the zero discharge concept is a large expenditure of money without improving the environment. Fortunately, the Act does not call for zero discharge as a National "policy". "Policy" as you know, is enforceable as a law and enforceable in the courts.

The Act calls for a goal of zero discharges by 1985. A goal does not have the effect or impact of law and is not enforceable in courts. Therefore, the goal is something we strive for and, if we do not quite make it because of the laws of economics and the laws of nature, okay -- we tried and at least came closer to utopia. So the Act as finally passed is an improvement over the original concept in the original Senate bill. The word "policy" in the original proposal has now been replaced by the word "goal" in the final Act as passed.

One of the key factors which will affect industry for the next decade or so is the definition of best practical control technology (BPCT) and best available control technology (BACT). As you know, the Federal Act requires that by 1977 all industrial wastes must receive the best practical degree of treatment. Further, the Act states that by 1983 all industrial wastes will receive the best available degree of treatment. Now, EPA and industry working together will need the wisdom of Solomon to define best practical degree of treatment which must be applied in the next several years to all industrial wastes. Developing these guidelines and standards which will define best practical control technology has, because of the compressed time frame, generated some controversy. Some industries feel the effluent guidelines are too strict and unrealistic. Obviously growing pains are inevitable in such a complex task compressed by the Act in such a short period of time.

The various contractors retained by EPA to define best practical control technology for industrial wastes are working closely with various trade associations representing industry. By and large it looks like reasonable guidelines will be developed after much discussion and debate. However, I would like to make certain points as follows:

1. EPA in developing the guidelines should keep them flexible with a considerable amount of discretionary authority in their application left to the individual regional administrators. Industrial plants vary considerably in their ability to reach various efficiencies of waste treatment. A new plant with good housekeeping might be able to obtain very easily the definition of best practical control technology. But what is the best practical control technology for a newer plant and process may not be the best practical control technology for an older plant with older processes. As long as the water quality of the receiving waters is protected, there should be a range of values which can be applied to plants depending on the process involved or their ages.

Many industries justify individual plants on the economies of that individual plant. If a tremendously high degree of treatment is going to be imposed at great expense on a plant which is older and perhaps only slightly better than marginal in its payoff, then it may be in the best interests of that company to shut down that plant. Jobs are lost and there is economic hardship without any appreciable improvement in the stream. The important thing in applying the definitions of BPCT to specific situations is to be sure the quality of the water is protected. As long as this is achieved, why shut down a plant just to adhere to rigid standards? Let's be flexible as well as just and fair.

2. Another factor which I think is very important in defining the best practical control technology comes in the terms and definitions used. The worst possible way to describe the quality of a discharge from industry is in terms of concentrations. A concentration says nothing about the total pounds of waste going into a receiving body of water and after all the effects on the receiving body will be determined by the pounds or quantity of waste going in and not the concentration. Furthermore, if we put limits on concentrations, then this discourages water conservation and encourages dilution by sloppy practices resulting in wasted water. Fortunately, I see EPA developing their definitions and their standards in terms of pounds of waste material per unit production. I would like to take my hat off to EPA for encouraging the contractors to talk in terms of quantities and not concentrations. On a number of occasions at the municipal and state level I have run into limitations on waste expressed in terms of concentration, such as ppm rather than in terms of pounds. When applied to such things as BOD and suspended solids, this is a rather meaningless limitation. It says in effect that a small discharge consisting of 10 gpm flow at 100 ppm BOD is no different from a discharge of 10,000 gpm flow at 100 ppm BOD. The fact that the latter discharge involves 1000 times more BOD in terms of pounds is totally ignored and neglected. It is the number of pounds of BOD, not concentration, which affects the water quality of the receiving stream. So let's forget concentrations as a limiting factor except in unusual cases.

Furthermore, if an industry discharged into a municipal system 10 gpm at 200 ppm BOD but the municipality limited the discharge to its treatment works to 100 ppm, the industry would tend to engage in sloppy procedures in the use of water in order to dilute down to 100 ppm BOD. The limitations in concentrations would encourage the industry to use once-through water so as to lower the concentration of its discharges down to 100 to be acceptable to the municipal system. Hence, we're discouraging what we want to encourage the most -- economic reuse and recycle of water. Only in the limited case of toxic material should concentration also be utilized as a control method.

The Act requires that EPA publish a list of what it considers to be toxic material and later establish standards of discharge for these toxic materials. This will prove a difficult and challenging job. EPA must use the most talented professionals in the field to carry out this extremely difficult task which can vitally affect industry.

And now a few specific points I'd like to discuss from my vantage point as an industrialist. First of all, the Act does correctly encourage the joint treatment of industrial and domestic wastes into large centrally located regional waste treatment systems, either run by the municipality or a public or private utility such as a sewerage district. The joint or combined treatment of wastes because of the economy's scale-up gives the best unit costs for waste treatment. Both the industrialist and the taxpayer gain by joint efforts. A proliferation of little waste treatment facilities, both industrial and municipal, is not the wisest approach to pollution control.

Now, although the Act encourages this joint approach, the Act also proceeds to require both sewer service charges for industrial wastes going into municipal systems and pretreatment requirements for certain industrial wastes going into municipal systems. These two requirements, while necessary, can, if made too restrictive and inequitable, kill the very concept that Congress has established in the Act. If the sewer service charges developed are inequitable and demand that industry pay more than its fair share of the costs, this might drive industry to treatment works of its own, thus killing the economies of joint approach. The industry pays a higher price for its own little treatment facility and the individual taxpayers will pay more for a municipal system that is smaller in size and does not enjoy the economies of scale-up.

Furthermore, if the pretreatment requirements for industrial wastes discharged to municipal systems are excessively stringent, then industry may be forced to needlessly treat its own wastes.

Pretreatment for pretreatment's sake should not be required of industrial wastes. Only those industrial wastes which are not effectively treated in a conventional municipal system or those industrial wastes having an adverse effect on the processes of a conventional municipal system should be pretreated prior to discharge to a municipal system for treatment by the municipality. All other wastes should be accepted into municipal systems for treatment by the municipality. This assumes that the capacity is available. In fact, even if the capacity is not available, it should be added to the treatment facilities to accommodate the industrial wastes at the expense of the industry involved. I want to strongly emphasize that we in industry do not want to be subsidized. We are willing to pay our fair and equitable share of waste treatment through an equitable sewer service charge.

At present, guidelines for pretreatment are being developed by EPA and its contractors. These guidelines during the preliminary review by a committee of the Water Pollution Control Federation looked fairly reasonable and practical. We have recommended certain changes in the, but by and large, they look good to me as an industrialist. The drafted guidelines protect the municipal system from abuse by industrial wastes and at the same time encourage industrial use of a municipal system.

I also know that various representatives of the Water Pollution Control Federation and certain other trade associations have reviewed the first draft of the sewer service charges by which industry will pay its fair share of waste treatment. This draft proposal also looks reasonably good but with certain inequities to industry still built in. We have forwarded our comments to EPA for their consideration.

And now I would like to pose two basic questions on the impact of the law on our economy and precious natural resources.

1. How do these national treatment standards impact upon the Nation's economy? In other words, what are the costs to achieve these goals?

2. What is the effect on these standards on energy? What are the energy requirements?

Before I answer these questions, I want to remind all of you again that total removal of waste to a receiving stream is unnecessary; all streams have a certain assimilative or self-purification capacity to destroy wastes without adverse affect on the water quality of the stream in question.

And now costs.....

It is not too expensive to remove perhaps the first 90 or 95% of the waste material from a discharge. However, to get the last one to three percent can involve tremendously escalating costs. It may take as much money to remove the last one or two percent as it did to remove the first 95 to 97%.

I have heard estimates ranging from 200 billion to three trillion as the cost of achieving the zero discharge goals as specified by the law.

To achieve secondary treatment alone in 1977 for all remaining municipal wastes not so treated will cost, by conservative estimate, about 60 billion.

And now let's grapple with the energy situation.....

It is estimated that the 1977 goals of B.P.T. (best practical technology or 90-95% removals) will increase electrical consumption by 20% or so. Remember this goal is easy; we've been doing it for years and the technology is available and yet even this easy goal will add 20% to our national electrical requirements. But how about the 1983 and 1985 goals of B.A.T. (best available technology or 95-99% removals) and zero discharge.

As slide I shows: 1) There is a tremendous increase of electrical needs as we go beyond 90% BOD removal. For example, at 95% BOD removal we may use about 0.7KWH/# BOD removal; however, going from 95 to 98% removal increases the electrical needs to 1.4KW. In other words, to get 3% additional BOD removal, we must double our energy consumption. I also think this table 2) emphasizes how power consumption escalates as we remove each additional percentage of pollutional load by waste treatment processes.

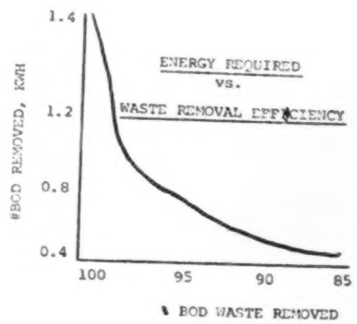
% REMOVAL RANGE	ENERGY REQUIRED FOR % POINT REMOVAL
to 87%	1
87 - 97%	10
97 -100%	100

Remember, PL92-500 does not even mention energy in the entire Act. The law was enacted in October, 1972 when the energy crisis was a small cloud on the horizon which no American wanted to even admit existed.

Well, how do we change PL92-500? It may be easier than you think. Congress, in enacting PL92-500, recognized the impact on our economy of trying to achieve the 1983 goals of best available control technology of 95 to 99% removals for all industrial wastes. Congress was aware that this clause in the Act is highly controversial as was the zero discharge clause. Therefore, in the Act Congress provided for a mid-course correction by late 1975. This correction will be achieved by a National Study Commission consisting of five members of the U.S. Senate, five members of the U.S. House of Representatives, and five members to be appointed by the President. Governor Rockefeller was appointed by President Nixon as a member from the general public and he is also Chairman of the Commission.

Governor Rockefeller's views are well known. Rockefeller intends to develop studies showing relative costs for each stage of stream clean up and an estimate of the benefit derived from the expenditures at each stage. Using costs and benefits he hopes this Committee can make sound, rational recommendations to Congress towards amending PL92-500. The Governor and his staff have stated that energy requirements as well as money will enter the picture in determining national goals in water clean-up efforts.

Each citizen should follow closely these studies and exert his influence towards effective, practical, and achievable national goals for cleaning up the nation's waters. A team effort consisting of all segments of our society is necessary to clean-up our environment at acceptable costs. Furthermore, the decision making process should be carried out by an informed public using information which we technical people generate.



NATIONAL COMMISSION ON WATER QUALITY

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I hardly know exactly what to say to this particular audience. I've tried to get some feel for what you might be interested in. I understand that there's already been some reference to the Commission. This organization was created by Section 315 of the Federal Water Pollution Control Act Amendments of 1972. It's origin relates to the dispute between the House and the Senate as to what should be done with the various deadlines or requirements of the Act. And so the Commission grew out of controversy. There was a decision to continue attention to the question of the effluent limitations that are prescribed for 1977 and 1983.

The Commission's direct charge as stated in Section 315 is to take a look at the 1983 requirements of the statute. The language reads as follows: The Commission shall "make a full and complete investigation and study of all the technological aspects of achieving and all aspects of the total economic, social, and environmental effects of achieving or not achieving the effluent limitations and goals set forth for 1983 in Section 301(B)(2) of this Act." That charge is very specific. The Commission is to look at the 1983 requirements. The Commission, however, early in its development, decided to also examine the 1977 requirements for both municipal and industrial discharges as they might impact achievement of the 1983 goal and requirements. In a similar way, the Commission determined also to characterize what was likely remain to be done after 1983 so as to reach the 1985 goal of the elimination of the discharge of pollutants into the nation's waters. The 1983 water quality goal is "that wherever obtainable, an interim goal of water quality which provides for recreation in and on the water be achieved" by that date. So that there is both a legal requirement for certain effluent limitations and a water quality goal for 1983.

The Commission was authorized an appropriation of $15 million of which $10 million has already been appropriated. There is, however, a statutory deadline for the Commission's report, October 18, 1975. Approximately six months elapsed before the presidential appointments were made and nearly a year elapsed before there was a staff board, at least enough staff to get underway. And so, one year of the Commission's three years had expired before the Commission really got its work started. The Presidential appointees, besides Gov. Rockefeller, are Dr. Edwin A. Gee, Executive Vice President, Du Pont, William R. Gianelli, recently retired director of the California Department of Water Resources, Raymond Kudukis, Director of Utilities for the city of Cleveland, Ohio, and the late Carl E. Wright, a member of the Arkansas Water Pollution Control Agency. Mr. Wright died recently of a heart attack and has not been replaced on the Commission. Senators from the Public Works Committee are Jennings Randolph from West Virginia, Muskie from Maine, Bentsen from Texas, Baker from Tennessee and Buckley from New York. The Congressmen from the House Public Works Committee are Blatnik from Minnesota, Jones from Alabama, Wright from Texas, Harsha from Ohio, and Grover from New York. The Executive Director is Gen. Frederick Clarke who retired last year as chief of the U. S. Army Corps of Engineers.

You will note from the makeup of the Commission that it includes in its Congressional membership three Democratic members from each of the Public Works Committees and two Republican members from each of those Committees. Its makeup is such that we have all shades of opinion with regard to the 1972 Water Pollution Control Act Amendments. In fact, the Commission members, I doubt seriously, could agree, at this point even, to the meaning of some of the language in the Amendments themselves. We've spent a great deal of time getting agreement on a very brief statement of the Commission's study outline.

If any of you are interested in getting a copy of this brief statement if you will give me your card before the night's over, or write your name and address on a piece of paper, I will be glad to have it mailed to you. It's a very brief statement of what it is the Commission expects to do. That statement is being elaborated in its various sections and those elaborations will be available to you or anyone who might have an interest in some particular area of the Commission's study.

Unfortunately, I suspect that one of the things that's happening is that everybody has some complaint about the effluent limitations, the EPA interpretation of the law, or some unexpected consequence of the statute. All somehow expect the National Commission on Water Quality to correct their problem as they see it. If we were to tackle all the problems that have thus far been mentioned to us I am sure that we could not complete the work of the Commission by the deadline. The mere addition of some examination of the 1977 requirements and the 1985 goal of the elimination of the discharge of pollutions will in themselves substantially add to what it is the Commission staff will have to do.

The Program Staff is organized into four major subject matter units: technology assessment, environmental assessment, economic and social impact, and institutional. There is also a unit responsible for program planning and coordination and the usual administrative support units, a general counsel, a public affairs staff, and the normal administrative services that have to be performed in organizations like this. We expect to have about 75 staff people and including staff assistants we now have about 65 of those on board. These staff assistants are selected primarily by the members, which is to say each member selects a staff assistant and he is resident with the Commission staff at the Commission offices. These assistants are assigned to various operating units depending upon their own training, experience and interests.

I want to devote some time to the specific study areas on which the Commission will concentrate. These are the areas where our efforts will be placed in terms of both money and time. Incidentally, we do not intend to do the work internally. We will contract with various concerns across the country to undertake this work for the Commission, so when I say the Commission will do these things, we will do these things under contract. Of the total appropriation of $15 million, about $12 1/2 million will be used for contract research with external organizations.

We begin with an attempt to describe the nation's water quality and quantity; we would like to establish a baseline of the nation's water quality as a means for examining future impacts of the elimination or reduction of pollutant discharge. This will be done under contract with concerns that have worked with water quality data and have the capabilities to predict future water quality based upon reduction or elimination of discharge of pollutants. This baseline will be used primarily for the environmental assessment of the impact of the 1977 and 1983 requirements as well as the ultimate goal of the elimination of discharges.

In the capabilities and cost of technology section, the staff is responsible for taking a look at the municipal treatment requirements as they relate to secondary treatment for 1977, and best practicable waste treatment technology over the life of the works for municipal treatment facilities for 1983. There will also be some attention to the question of the possibility of the elimination of discharge from municipal waste treatment facilities. When I say elimination in terms of municipal wastes, however, this does not mean the removal of the pollutants themselves, but the possibility of disposal by methods other than the direct discharge into receiving waters. For industries, we will do an analysis of all of the effluent limitations and the economic bases produced by EPA for the effluent limitations. When I say we'll do all of them that means we'll take a look at all the classifications EPA has delineated and all the effluent limitations prescribed for those classifications. Obviously we will devote more attention to some than to others. We already have selected as many as six or eight to which we will devote special attention and these are those classifications where the waste discharges are substantial or their polluting effect is substantial or they represent significant segments of the economy. In some sense this means we will attempt to second guess EPA's effluent limitations and I suppose there is no way to avoid that impression. We will begin first with the economic analysis to determine whether or not that analysis appears to be reasonable. There will also be a look at the technological solutions recommended in the development documents produced by EPA to determine whether or not there might be other technologies that could be utilized. Now we have not yet crossed the bridge of whether we will attempt to develop, or might be in a position where we would have to develop, alternative technologies that would set at different effluent limitations for some of these industrial classifications. Our general feeling is that we would merely point out the problems that arise with the effluent limitations as prescribed by EPA. If we do, in the course of the work, develop some impressions as to what the effluent limitations should have been, we may very well furnish that information first to the EPA but it could conceivably end up eventually in the Commission's final report. That's primarily the work of the cost and capabilities technology section. Their product or the product of their work, the costing of these various effluent limitations, will become the input for the economic analysis that is required under the statute.

For the economic analysis, we will also attempt to develop projections of gross national product and government and income expenditure to 1985. This is a year-by-year projection as a basis for attempting to determine the impact of the cost of the effluent limitations. Using the information produced by the cost and capabilities technology unit, the economic unit will them attempt to trace the cumulative effect of all the industries trying to meet both the 1977 and 1983 requirements simultaneously, and make some determination as to the impact upon governmental income and expenditure, particularly as that item is affected by the municipal waste treatment construction grants program.

For environmental assessment, the Commission will attempt to characterize what should be the chemical, physical, and biological composition of the water that is necessary restore and maintain the integrity of the nation's waters, which is a phrase used in the statute and what would be required in order to meet the statute's water quality objective. In the economic impact analysis, we will use econometric input/output models, where they are available; and we have determined to use the one that presently is housed in the EPA called "SEAS" with some additions which will be developed and funded by the Commission. Now modeling, we recognize, is merely one of several tools that can be utilized in this area. In the ecological or environmental area, models are less developed and have less reliability perhaps but we will examine the possibility of utilizing such models as do exist. But in the environmental arena this work will be primarily done as a series of analytical processes rather than an attempt to perfect any existing modeling effort. The assumption will be made that the 1977 requirements will be met whether they are met in '77 or later, and that the 1983 requirements will be met whether they are met in '83 or later. An attempt will be made to characterize what will then be the quality of the nation's waters if those effluent limitations were reached. We will also attempt to characterize what would be the quality of the nation's waters if the elimination of discharge of pollutants was realized at any date. The purpose is to try to compare what might have to be spent to reach, in terms of cost, of what the cumulative economic effect might be, of reaching the 1977 and 1983 requirements and the elimination of the discharge of pollutants -- what might be the benefit that might be realized in terms of environmental change.

The environmental assessment is probably the one that's most difficult to do, unless it's the social impact question. We recognize that the reaching or not reaching the 1983 requirements and other requirements and goals of the Act can have social impact. One of the things we are concerned with is what happens in those instances where marginal industries close as a result of the effluent limitations and on the other side of the equation what benefits accrue as the result of improved water quality. The utilization of leisure time in terms of water-oriented recreation, the health effects of changes in water quality, and even questions of shift in employment as a result of achieving or not achieving the effluent limitations will be examined.

In the institutional area, the Commission's concern is to try to evaluate the federal, state, regional, local arrangements for achieving water quality objectives, and try to determine whether or not these could be improved, in a realistic sense rather than in an idealistic sense, and how the system might be tied together better so that the work is concentrated on achieving improvement in water quality rather than a lot of energy used up in irritations, and abrasions, and frustrations between the various levels of government. The institutional area is one in which a number of Commission members have an interest, several of us on the staff have been involved in various levels of this type of administrative effort and we also have an interest in the institutional question. Some hope that this will be the most fruitful part of the Commission's work but one of the problems with institutions is that they don't change rapidly. We have, in the water field, had a multiplication of water agencies rather than a dimunition of water agencies. This tends to complicate the interrelationships at all levels of government.

The regional assessment studies we originally conceived as a means for trying to relate what otherwise would be national statistics and implications to some geographic areas so that people could determine what was the impact of this particular statute on their locality. We looked initially for representative bodies of water, lakes, rivers, and coastal areas, to which we felt others might be able to relate. We started with a rough list of 36 in the country intending to select as many as ten. Over time, the concept of the regional studies has changed somewhat. With 15 Commission members coming from different parts of the nation's geography there is always a pressure to get a river in "my" area, and there's been some of that type discussion. It is also probably true that where we might see similarities I am not sure that residents in the various areas would see the same thing. They may not be as representative as we had hoped they might. They may be more illustrative of what the problems are likely to be. One of the things I think that happens in evaluating a national program like this is that a national statistic doesn't touch you. If I say that the cost of this program is going to a $100 billion over the next five years that does not necessarily hit any one of us except that that's a pretty substantial figure. But if I were to tell you that it was going to cost you $17.30 a month for the next ten years, that is a figure that has a great deal more impact on you individually. We had hoped that we would be able to disaggregate, if you will, the national statistics we inevitably will come up with. I think we will have some success with this but the character of these various regional assessments is undoubtedly changing and will change as we attempt to scope them.

I'm going to give you the names of the various regional studies we will do with the understanding that we have not yet scoped these, one of these were only chosen a week ago Wednesday, and we get approval from the Commission before we detail what is to be done in each one of these areas. Each one will be scoped to where it is manageable; that is to say, we will scope these in such a way that we concentrate on the differences where the differences are important but we also would attempt to do a fairly uniform analysis where the data will support that approach. In other words, these could be microcosms of the national study in some of the regional areas. The rivers are the Merrimac, Nashua, the Hudson, the Delaware, the Kanawha, a tributary of the Ohio, the main stem of the Ohio from Pittsburgh to Cairo, Lakes Michigan and Erie (that one obviously will have to be narrowed considerably), the Chatahoochie Flat-Appalachicola system along the Alabama/Georgia border, the Houston ship channel-Galveston Bay, the Colorado River (obviously is a massive one, but one that we felt was absolutely necessary because of the question of irrigation water use, the normal background salinity that comes from runoff, and the potential development of oil shale in the upper basin), and the Yellowstone, a tributary to the Missouri -- selected largely because it is as yet undeveloped. However, the coal deposits in Montana that will ultimately or may ultimately be developed as a result of the pressure and demands for increased energy will undoubtedly have an impact on the Yellowstone. The intent here was to pick one undeveloped river basin subject to development to characterize that particular type of environment. The San Francisco Bay/Central Valley is one that is obviously too large geographically, but does represent a significant bay system along with a complex of irrigation and industrial discharges. Lake Washington/Puget Sound was chosen primarily because this is one area in the country where there have been substantial improvements over time in water quality, done largely by reducing the discharges of pollutants.

As to what's likely to come out of what the Commission does, obviously when you hear it, and when we read it and even when we discuss it, there appears to be entirely more than can be done in the time we have. I generally have encouraged the program staff to be broader rather than narrower in their initial undertaking, recognizing that over time some of things we would like to do will fall by the wayside simply because of the absence of adequate data or methodology, in some cases. Whether or not we can produce something meaningful is also related to the political issues involved. I make no secret of the fact that we have at least four potential presidents, vice presidents, or candidates on the Commission. They are evenly divided so far between Republicans and Democrats. That has a bearing on what the Commission sees as the Commission's role. I will admit that it has been very difficult at times to get Commission agreement on some very, what appear to be, very simple language, what you would regard to be relatively simple language, because of the history of the development of the statute itself. So there is a political hazard in what we are undertaking. As to the expectation that people have about what it is the Commission can do for them, we already have had massive contacts from industry about the effluent limitations; we have had extensive contacts with environmentalists and public interest groups; and from the states themselves as to the progress of this program. We in fact have in the public affairs unit an individual -- one person full time -- in each of those areas. We have a full time liaison with industry, a full time liaison with the environmentalists and public interest groups, and a full liaison person for all governmental levels -- federal state, local and regional governmental units, simply because of the pressures that these people feel and would like to exert in terms of what the Commission might ultimately report.

The staff does not, at this point in time, intend to develop recommendations. That is to say, none of our work programs will be scoped so as to get recommendations from contractors. The staff does intend, and I am committed to the professional staff people who have been brought on board in these various subject matter units, that they will be allowed to produce a professionally sound document. The staff intends to write the initial Commission report. Whether or not we achieve that is also involved in a general question of the relationship of the staff to the Commission. Undoubtedly the question of recommendations will come, the question of recommendations will undoubtedly occur and we will I am sure develop impressions. Some of us on the staff begin with biases. The point I make about mine is that mine are really objective opinions and I am just combating all those other biases I encounter. But, it's hard to avoid them if you've had any exposure to this program before.

There is a real opportunity for a group like this to make a contribution and because the Commission is made up in an unusual way, a mix of Congressional members with Presidential appointees, it has an opportunity to do something that not all Commissions have had. You've heard of Executive Commissions where they develop detailed recommendations and nothing ever happens. Well, one thing for sure, if this Commission can develop recommendations that the Congressional members support, we can expect that those members will see to it that these recommendations will at least get introduced to the Congress. On the other side of the coin, if this Commission develops recommendations that the Congressional membership will not support, then obviously there is little chance of making an impact on the law itself. And I would remind you, if by virtue of the accident of the way the politics lines up, there is or there could be, a majority if you split on partisan lines, there would be a Republican majority on the Commission, with two from each House and five Presidential appointees, presumably all Republicans; that would give a majority of nine, which would be a controlling majority if the issue were split strictly on party lines. I would hasten to add that this statute has not been handled that way, generally speaking. The statute generally has been rather substantially supported in the Congress and I would not anticipate that the issue will be raised in such a way, if I can get them formulated properly, that the issues will not be raised in such a way as to encourage the possibility of a split along party lines. It makes some difference the way an issue is framed but certainly that possibility does exist.

SESSION III: CONTROL TECHNOLOGY

Moderator:
A. Trakowski
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A SYSTEMS ANALYSIS FOR SO_x CONTROL TECHNOLOGY RESEARCH & DEVELOPMENT*

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SUMMARY

A systems analysis of SO_x stationary source control technology is being developed with several objectives in mind:

> To gather all available information and forecasts on SO_x emissions, applicable control technology, costs and standards into a versatile easy-to-use system of data and models.
>
> To determine the economic, environmental and energy impact upon the Nation of applying the most appropriate SO_x control technology to existing and near future emission sources such that standards are met in an economic fashion.
>
> To project and quantify the potential benefits of possible SO_x control technology R&D on the capability to meet standards and to assess the economic, environmental and energy impact of this compliance with standards.
>
> To allocate resources within budget constraints toward that R&D which has the highest potential benefit for reasonable cost and risk.
>
> To assist the energy generating and consuming communities in developing environmentally and economically sound plans for future growth.

The system will include an emissions inventory for major sources of SO_x and cost and performance models for SO_x control technologies. These technologies include flue gas cleaning, coal cleaning, coal conversion to gas or liquids and process or combustion modifications. Forecasts will be used to project the growth of the major emission sources of SO_x, to estimate the time of availability of certain control technologies, and to indicate the most promising areas for R&D. The system will be capable of determining the most applicable control technology for a particular source, and selecting an optimum design which meets SO_x standards while minimizing cost and other impacts. For a set of R&D programs, the system will determine and rate the sensitivity of cost and the other impacts to each (or combinations) of these programs. The system can also evaluate the impact of potential future occurrences, such as changes in standards, energy shortages, and construction limitations.

A summary of the development work performed to date and planned for the future is presented.

INTRODUCTION

As required by the Clean Air Act of 1970, the Environmental Protection Agency named SO_x as one of the major air pollutants to be controlled. For several years before this, however, R&D was being performed by government and private industry to develop technologies which could be used to control sulfur oxide emissions. To date, approximately $120 million has been spent by government and private industry on research and development work directed at controlling SO_x from stationary sources, which account for 97% of the total SO_x emissions. Over 100 different processes have been proposed and developed, at least to the bench scale, for removal of SO_x from stack gases. Similarly, numerous processes for removal of sulfur and sulfur compounds from fuels and raw materials have been investigated. Finally, modifications of and alternatives to the combustion process and other industrial processes have been considered which reduce the amount of sulfur oxide formation.

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A summary of the nationwide emissions of SO_x is shown in Table 1 for the year 1971. SO_x comes primarily from combustion; i.e., the electric utilities, industrial heating and steam raising, commercial, institutional and residential space heating and incineration of wastes account for 82% of emissions.

Presently, eight technology areas are considered to be usable for control of SO_x emissions. These are:

1. Stack gas scrubbing with throwaway scrubbing agents.
2. Stack gas scrubbing with regeneration of the scrubbing agent.
3. Physical or mechanical coal cleaning.
4. Chemical coal cleaning.
5. Production of a sulfur free high-Btu gaseous fuel (substitute natural gas) from coal or oil.
6. Production of a sulfur free low-Btu gaseous fuel from coal or oil for use in an advanced power cycle electricity generation process.
7. Production of a low sulfur liquid fuel from coal.
8. Desulfurization of high sulfur oils.

For each of these technologies, there are a number of different processes in varied stages of development, many with government support. For example: five stack gas scrubbing processes are being demonstrated at pilot or commercial scale with EPA support. Six more are in the planning or construction phase.

Table 1. ESTIMATED NATIONWIDE SO_x EMISSIONS, 1971

Source	10^6Ton*/year	10^6Mg/yr	%
Transportation	1.0	0.9	3.0
Electric utilities	20.1	18.2	59.6
Industrial combustion	4.2	3.8	12.5
Res./comm. combustion	2.1	1.9	6.2
Smelters	4.0	3.6	11.8
Sulfur recovery plants	0.9	0.8	2.7
Sulfuric acid plants	0.6	0.6	1.8
Other industrial processes	0.6	0.6	1.8
Solid waste disposal	0.1	0.1	0.3
Miscellaneous	0.1	0.1	0.3
TOTAL	33.7	30.6	100.0

*Although EPA policy is to express all quantities in metric units, this paper uses a few non-metric units for convenience. Users familiar with the metric equivalents should use the following factors:

Non-metric	Multiplied by	Equals metric
Btu	252.00	cal.
°F	5/9(°F-32)	°C
lb	0.45	kg
ton	907.18	kg
ton	0.90718	Mg

A SYSTEMS ANALYSIS

It is clear that considerable R&D is being performed on SO_x control technologies, and yet more will be required before the SO_x emission problem is overcome, especially from non-utility sources. The task of allocating R&D funds for SO_x pollution control in an optimum manner is complex and difficult. It is being done each day, however, by government and private industry. This task is further complicated by the rapid changes in energy availability, national regulation and economic growth.

A flexible, versatile tool is being developed in the form of a systems analysis to assist in allocating R&D funds and making other decisions in light of uncertain future. Specifically, the system analysis for SO_x control technology has several objectives:

1. To gather all available information and forecasts on SO_x emissions, control technology, cost and standards, into a versatile and easy-to-use system of data and models.
2. To determine the economic, environmental and energy impact upon the nation to apply the most applicable SO_x control technologies to existing and near future emission sources such that standards are met in an economic fashion.
3. To project and quantify the potential benefits of possible SO_x control technology R&D on the ability to meet standards and to assess the economic, environmental and energy impact of this compliance with standards.
4. To allocate resources within budget constraints toward that R&D which has the highest potential benefit for reasonable cost and risk.
5. To assist the energy generating and consuming communities in developing environmentally and economically sound plans for future growth.

A decision analysis methodology will be used to achieve objectives 3 through 5, which will start with an organized information base (objectives 1 and 2) containing today's knowledge about emissions, control technology, costs and standards. This data and information base is called a "deterministic model" because it enables a specific, unique answer to be determined based upon today's knowledge. The deterministic approach fails when applied to areas influenced by future variables as is the case in R&D allocation. To assess events in 1980, a range of values for future variables should be considered. This can lead to excessive computation to explore the entire range of each uncertain future variable.

The uncertainty in the value of a future variable can be represented by a probability curve. A "probabilistic approach" can then be used to determine an answer also in the form of a probability curve. This is computationally feasible and also defines the uncertainty in the value of the answer. The probabilistic approach is well founded in the science of decision analysis and can be implemented using the technique of decision tree analysis. Typical future variables should include: 1) the availability of coal, 2) the availability of clean fuels, 3) the cost of coal, 4) the cost of limestone, 5) sulfuric acid demand, 6) labor costs, and 7) levels of enforcement on SO_x abatement.

The systems analysis will also contain an "information phase" which will determine the benefit of obtaining better information in terms of reducing the uncertainty of the answer. An example of better information would be reducing the uncertainty in the value of a future variable by narrowing its probability distribution. The value of additional information could then be compared by the cost of obtaining it.

A SYSTEM OF DATA AND MODELS

At present, the deterministic phase exists as a system of data and models of emissions, control technology and costs. The data base consists of a stationary source emissions inventory based on 1971 data for:

1. Utility boilers.
2. Industrial boilers.
3. Smelters.
4. Sulfur recovery plants.
5. Acid plants.

The sources of the data are the EPA's National Emissions Data System (NEDS), which contains some confidential data obtained from industry, the Federal Power Commission For 67 data, the National Coal Association 1972 edition of Steam-Electric Plant Factors, Chemico's report on Engineering Analysis of Emission Control Technology for Sulfuric Acid Manufacturing Processes and Processes Research Incorporated's report on Characterization of Claus Plant Emissions.

From the SO_x emissions inventory, some statistics were generated. Six states representing 29% of the total U. S. utility capacity contribute 54.5% of the utility sulfur emissions. These states are Ohio, Pennsylvania, Illinois, Indiana, Kentucky and Michigan which are all centered around major coal fiels of the U. S. Of the total U. S. utility sulfur emissions, 95.4% come from 22 states, all in the eastern half of the country. Table 2 gives a national breakdown of the utilities fuel consumption in 1971. Only 7.5% of the total fuel was burned in exclusively gas fired boilers which would not need some form of SO_x control. The remaining gas was used in multiple fuel boilers.

Table 2. FUEL BURNED BY UTILITIES IN 1971

Plant size MW	Coal %	Oil %	Gas %
0-100	2.11	0.65	2.89
101-200	3.02	1.57	3.06
201-400	7.68	3.07	4.62
401-600	9.29	3.52	4.66
601-800	6.37	2.33	3.03
801-1000	4.58	1.69	5.15
1001-1200	7.03	0.68	1.21
1201-1400	4.02	0.60	2.04
1401-1600	1.91	0.95	1.09
1601-3000	8.59	1.05	1.54
	54.60	16.11	29.29

Figure 1 shows that significant reductions can be made to the national utility SO_x emissions by cleaning up relatively few of the largest plants. For example, 75% of the utility SO_x emissions come from approximately 200 plants (sizes greater than 400 MW) and 90% come from 350 plants (sizes greater than 200 MW).

The SO_x emissions from the respective smelters are shown in Table 3. Three states contribute 65% of the total U.S. non-ferrous smelting industry SO_x emissions -- Arizona, Texas and Montana. In addition, approximately 50% of the emissions comes from the 10 largest plants which are over 125,000 tons/year capacity whereas 75% comes from 20 plants which are over 75,000 tons/year. There are 36 plants in the U.S. with a total capacity of 3.6 million tons/year

Table 3. SO_x EMISSIONS FROM SMELTERS

Smelters	10^6 Tons/Year	%
Copper	3.0	75.0
Zinc	0.7	17.5
Lead	0.3	7.5
	4.0	100.0

The industrial boiler emissions inventory is incomplete because several major states are missing from the data base. Therefore no statistics are available. However, work is currently underway to complete this inventory.

The SO_x emissions from sulfuric acid plants depend upon type of plant, raw feed material and type of product but are in two forms -- acid mist and sulfur dioxide. Three southern states -- Florida, Texas and Louisiana -- contribute 41% of the total U.S. acid plant SO_x emissions. In addition, 50% of the emissions come from the 50 largest plants which have over 800 tons/day capacity and 75% is accounted for by adding the next 50 plants over 450 tons/day capacity. There are 251 plants with a total capacity of 11,000 tons/day.

As with the other industries, a significant reduction in emissions can be achieved by cleaning up relatively few sulfur plants. The 15 plants over 300 tons/day capacity account for 50% of the sulfur emissions whereas the next 25 plants of size 120 to 300 tons/day comprise the next 25%. There are 164 plants in the U.S. with a total capacity of 17,650 tons/day.

Six SO_x technology areas have been considered to date for inclusion in the system. These are:

1. Throwaway flue gas cleaning (wet limestone scrubbing process).
2. Regenerable flue gas cleaning (Wellman-Lord/Allied Chemical process).
3. High-Btu gasification (Lurgi coal gasification process).
4. Chemical coal cleaning/coal liquefaction (solvent refined coal process).

5. Low-Btu gasification with advanced power cycle (Lurgi coal gasification process).
6. Modified combustion techniques (Westinghouse Research Labs fluidized bed combustion process).

Detailed cost models have been developed for the processes associated with the first four technology areas. These technologies are all applicable to new or retrofit installation on combustion sources. The latter two technologies are applicable to new combustion/power generation facilities only. Cost estimates have been developed for these. The two flue gas cleaning processes are applicable to smelters, acid plants and sulfur plants; however, the regenerable process is more likely to be used.

The process and cost models were prepared for the four processes by relating the key process variables (design capacity, operating rate, % sulfur, etc.) with equipment sizes, utility consumption (cooling water, process water power, natural gas and steam), raw material requirements, and byproducts, if any. The cost models estimate the total capital investment and the annual operating costs. The total capital investment is a function of the key process variables, the retrofit difficulty factor and the location. The relationships in these models for total capital investment and total operating cost are shown in Figures 2 and 3.

The cost models have been developed using U.S. Gulf Coast 1973 costs as a basis. In order to predict plant costs for other locations, factors have been developed which relate construction labor costs at various locations to Gulf Coast labor costs. Table 4 lists the relative labor costs as determined for twenty-one cities. Table 5 lists average location factors for each state. Costs are generally highest in the Northweastern quarter and lowest in the South and Gulf areas. Total plant investment (TPI) is related to major equipment costs, E, other material costs, M, labor and costs, L, and location factor, F by the following equation:

$$TPI = a\ (E + M) + b\ L\ F$$

when the coefficients a and b generally range in value from 1.29 to 1.55 and 1.60 to 1.92 respectively and the higher values represent a 20% contingency for the uncertainty which might exist in a new process.

The cost models for the wet limestone process and the Wellman-Lord/Allied Chemical process were applied to utility boiler emissions inventory to determine the capital and operating costs to control SO_x emissions from each plant. The boilers in a plant were visualized to be retrofitted with scrubbing equipment beginning with the largest boiler until the overall plant emissions were less than 1.2 lbs SO_2 per million Btu of fuel burned by the plant. Assumptions were made concerning load factors, fuel split and retrofit difficulty within a plant. The total capital required in $/KW of plant capacity and the incremental cost of electricity in mils/Kwh due to the stack gas scrubbing are shown in Figures 4 and 5 for the two processes. The costs shown here are not the costs for controlling the total plant capacity but rather for controlling enough boilers to meet the specified emission level. The location factor has been incorporated into these calculations.

The results of exercising the cost models for high-Btu SNG (substitute natural gas) production and for solvent refined coal indicated that plant location and coal cost have the largest effect on the gas cost while percent sulfur and coal type have a slight effect. Costs increase with sulfur content of the coal (1.5 to 2¢ per %) and increase with decreasing coal quality, i.e. gas cost is less for bituminous coal than for lignite. Figure 6 gives a comparison of costs for the two products for mine mouth plants. The costs of SNG are given an accuracy of plus or minus 10% or 8 to 11¢/MMBtu whereas the costs of SRC are given 30% or 18 to 24¢/MMBtu. These accuracies are based upon the state of development of the processes.

Cost models have yet to be developed for the low-Btu gasification process with combined cycle power generation and the fluidized bed combustion process. In addition, some of the cost models need modification to make them applicable to other emission sources beside utilities. Cost models may also be developed later for technologies such as physical or mechanical coal cleaning, desulfurization of high sulfur oils or residual oil gasification.

Table 4. LABOR COST LOCATION FACTORS FOR MAJOR U.S. CITIES

Location	Location Factor
Atlanta	1.10
Baltimore	1.41
Birmingham	1.16
Boston	1.23
Chicago	1.52
Cincinnati	1.53
Cleveland	1.86
Dallas	1.07
Denver	1.03
Detroit	1.73
Houston	1.00
Kansas City	1.37
Los Angeles	1.44
Minneapolis	1.54
New Orleans	1.16
New York	2.08
Philadelphia	1.82
Pittsburgh	1.52
St. Louis	2.01
San Francisco	1.45
Seattle	1.21

Table 5. AVERAGE LABOR COST LOCATION FACTORS FOR EACH STATE

State	Location factor	State	Location factor
Alabama	1.2	Missouri	1.6
Alaska	2.1	Montana	1.3
Arizona	1.3	Nebraska	1.4
Arkansas	1.2	Nevada	1.4
California	1.5	New Hampshire	1.2
Colorado	1.2	New Jersey	2.1
Connecticut	1.7	New Mexico	1.3
Delaware	1.4	New York	2.1
D. C.	1.4	North Carolina	1.2
Florida	1.2	North Dakota	1.3
Georgia	1.1	Ohio	1.6
Hawaii	2.0	Oklahoma	1.4
Idaho	1.3	Oregon	1.2
Illinois	1.7	Pennsylvania	1.6
Indiana	1.6	Rhode Island	1.3
Iowa	1.5	South Carolina	1.1
Kansas	1.4	South Dakota	1.3
Kentucky	1.5	Tennessee	1.2
Louisiana	1.1	Texas	1.1
Maine	1.2	Utah	1.2
Maryland	1.4	Vermont	1.2
Massachusetts	1.3	Virginia	1.4
Michigan	1.7	Washington	1.2
Minnesota	1.5	West Virginia	1.5
Mississippi	1.1	Wisconsin	1.5
		Wyoming	1.3

Table 6. PRODUCTION GROWTH IN SO_x EMITTING INDUSTRIES

Industry	1972 Production (10^6 tons)	1960-1972 Growth Rate (%/yr)	1980 Production (10^6 tons)
Copper smelting	1.87	1.7	2.40
Zinc smelting	0.76	-0.4	?
Lead smelting	0.65	4.9	0.85
Sulfuric acid	31.5	4.9	46.0
Sulfur recovery	1.9*	4.2	2.7*

*long tons

PROJECTING INTO THE FUTURE

To achieve the objectives that were mentioned earlier, the systems analysis requires considerable information about the future. This future information includes the following:

1. Cost and availability of fuels.
2. Growth of the major SO_x emitting industries.
3. Time of availability of different control technologies.
4. R&D investment required to develop or improve each control technology.
5. Probability of success of R&D.
6. Changes in emission standards.
7. Availability of capital.
8. Investment, fabrication and construction lags in each industry.

Several techniques exist for forecasting or predicting the future. Four techniques have been used or will be used in this system analysis. These are:

1. Trend extrapolation.
2. Delphi.
3. Encoding of uncertainty .
4. Impact analysis.

Trend extrapolation has been used to predict the growth of the major SO_x emitting industries. For example, the total electric power production in the U.S. is projected to increase at the same rate as today; that is, by 7.0% per year through 1985. However the growth of conventional thermal plants will drop to from 7.6%/year in the 1960-1970 period to 5.5%/year after 1980 and 4.4%/year after 1985, with nuclear plants showing growths of 12.7%/year and 13.5%/year after 1980 and 1985 respectively. These projections are based on historical growth rate and do not take into account the possibility of reduced electrical demand due to energy conservation programs or increased demand to supply environmental upgrading programs.

Trend extrapolation indicates that industrial boiler capacity growth should be 3.5%/year with the breakdown being 2.1%/year for coal fired, 5.2%/year for gas fired and 1.4%/year for petroleum product fired. However, this does not take into account the fuel shortages or the possible actions to make boiler operations more efficient as a result of high fuel prices. Table 6 shows the projected growth of several industries.

A panel of experts was set up and Delphi techniques were employed to make projections about R&D programs for SO_x control which are underway or anticipated. The Delphi technique consists of providing the panelists with a stimulus in the form of a questionnaire which requires them to make projections about the future. The answers must be numerical in form but may consist of specifying the range of the answer rather than a specific value. A statistical analysis of the answer from the panelists is made and this serves as a basis for a second questionnaire. This questionnaire is aimed at making the panelists rethink their answers and revise them toward reaching a consensus, if that is possible. Subsequent rounds are used to further improve the answers and reach a consensus wherever possible.

The Delphi technique was used to consider eight SO_x technology areas -- throwaway and regenerable flue gas scrubbing, high and low Btu gasification, coal liquefaction, physical and chemical coal cleaning and fluidized bed combustion. Within each area the following subjects were explored:

1. Applicability of the technology to different emission sources.
2. Timing of commercial acceptance.
3. Cost and timing to successfully complete major R&D programs and projects.
4. Probability of success of these major R&D programs and projects.

Some useful information was obtained by the Delphi technique especially with respect to the application areas, the probability of success and some of the timing. The Delphi forecasts of pollution control technology usuage by coal fired utility boilers and of markets for coal conversion products in year 2000 are shown in Tables 7 and 8. But on the whole, it was not successful. The major reason for the lack of success was that the subject matter was too broad. The panelists were selected so that the broad range was covered; no panelist, however, was knowledgeable enough in all subjects. Therefore only a few could contribute to each subject. The broad subject matter also led to lengthy questionnaires which required much more time to complete and to analyze than was originally anticipated. The overall conclusion was that Delphi is a viable technique if the subject matter is relatively narrow and if there is adequate time available to complete the number of rounds required to reach an acceptable consensus.

Table 8. DELPHI FORECAST OF MARKETS FOR COAL CONVERSION PRODUCTS

Market	%
High Btu Gas	
Residential	60
Commercial	25
Industrial	14
Other	1
TOTAL	100
Low Btu Gas	
Commercial	2
Industrial	24
Utility	74
TOTAL	100
Liquid Fuel	
Utility	29
Refinery	66
Other	5
TOTAL	100

It is currently felt that more success may be possible by using a personal interview of an expert by a trained observer to extract future projections and to encode the uncertainty in these projections. A statistical analysis can be used on the results of several interviews to obtain the desired future information in the form of a probability distribution. Methods of encoding uncertainty either require the expert to assign probabilities

Table 7. DELPHI FORECAST OF POLLUTION CONTROL TECHNOLOGY BY COAL-FIRED UTILITY BOILERS IN YEAR 2000

Control Technology	Coal Consumption (10^{15} Btu)	%
Flue gas cleaning	5.9	33.7
Coal cleaning	3.6	20.6
Combustion modifications or advanced combustion system	3.5	20.0
Other	0.8	4.6
No control	3.7	21.1
TOTAL	17.5	100.0

to a range of values or to assign values to a range of probabilities. However this can be done in an indirect manner where the expert answers a series of simple questions which involve choosing between two or more alternatives. The answers are then translated into a probability distribution. It is planned to use this technique to reinforce and supplement the future information which was obtained from trend extrapolation and Delphi.

The impact analysis methodology is a technique for tracing the relationship between future variables. This methodology employs experts to encode the relationship between future events that can affect a major variable. For example, consider the following items which would affect the price of coal in 1980:

1. Costs of coal in 1979.
2. Wages of miners.
3. Prices of competitive fuels.
4. Demand for coal.
5. Rate of inflation.
6. Energy crisis worsening or slackening.
7. Deep mines or strip mines.

In an impact analysis, the experts consider the items in the list two at a time and rate the impact of one upon the other and vice versa. Possible ratings would be:

1. Strongly and positively related.
2. Strongly and negatively related.
3. Moderately and positively related.
4. Moderately and negatively related.
5. Weakly and positively related.
6. Weakly and negatively related.
7. Unrelated.

The effect of one variable upon a second would not necessarily be the same as the effect of the second upon the first. With this information and probability distributions for the values of each of the variables, statistical analysis can be used to project the cost of coal in 1980 and the sensitivity of this cost to the other variables. This technique will also be employed in the development of the probabilistic phase of the systems analysis.

CONCLUSION

A systems analysis methodology is being developed for evaluation and comparison of SO_x control technologies and SO_x R&D decision making. The system should be available for use toward the end of this year. The systems analysis will have the following structure:

1. Deterministic phase.
    a. Emissions inventory.
    b. Process and cost models for control technologies.
    c. Emissions standards.
    d. Fuel availability and allocation.
    e. Sensitivity analysis of processes and costs.
2. Probabilistic phase.
    a. Projections about future costs, emissions and standards.
    b. R&D costs, timing and probability of success.
    c. Applicability and availability of technology.
    d. Impact analysis of future variables upon one anotner.
3. Informational phase.
    a. Value of new information and improving existing information.
    b. Cost of obtaining new or better information.
4. R&D allocation phase.
    a. Rank R&D programs by benefit/cost and other impacts.
    b. Sensitivity analysis of R&D timing and level of resources.

The system will be capable of determining the most effective control technology for a given source and select a design which meets SO_x emission standards while minimizing cost and other impacts. In the allocation of resources to R&D programs, the system will permit R&D programs to be rated and ranked as to benefit, cost and other effects. The sensitivity of R&D timing and level of funding can also be explored.

ACKNOWLEDGEMENT

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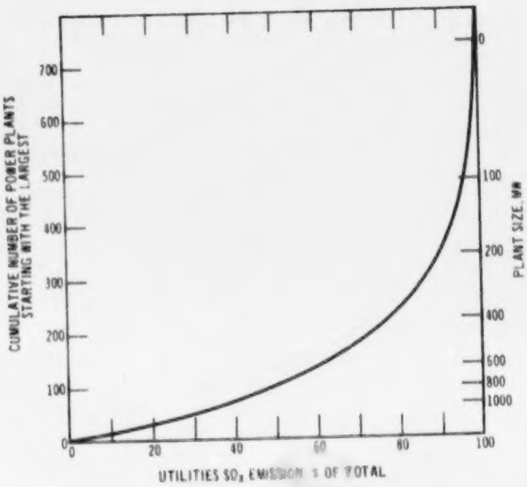

Figure 1. U.S. utility industry SO_x emissions.

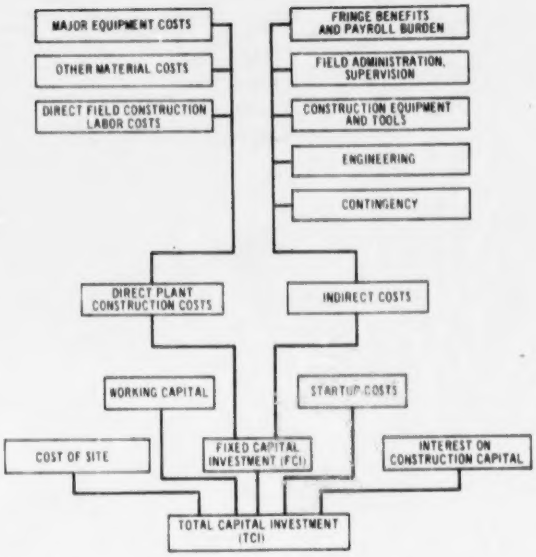
MAJOR EQUIPMENT COSTS
OTHER MATERIAL COSTS
DIRECT FIELD CONSTRUCTION LABOR COSTS
FRINGE BENEFITS AND PAYROLL BURDEN
FIELD ADMINISTRATION, SUPERVISION
CONSTRUCTION EQUIPMENT AND TOOLS
ENGINEERING
CONTINGENCY
DIRECT PLANT CONSTRUCTION COSTS
INDIRECT COSTS
WORKING CAPITAL
STARTUP COSTS
COST OF SITE
FIXED CAPITAL INVESTMENT (FCI)
INTEREST ON CONSTRUCTION CAPITAL
TOTAL CAPITAL INVESTMENT (TCI)

Figure 2. Relationship between factors included in total capital investment.

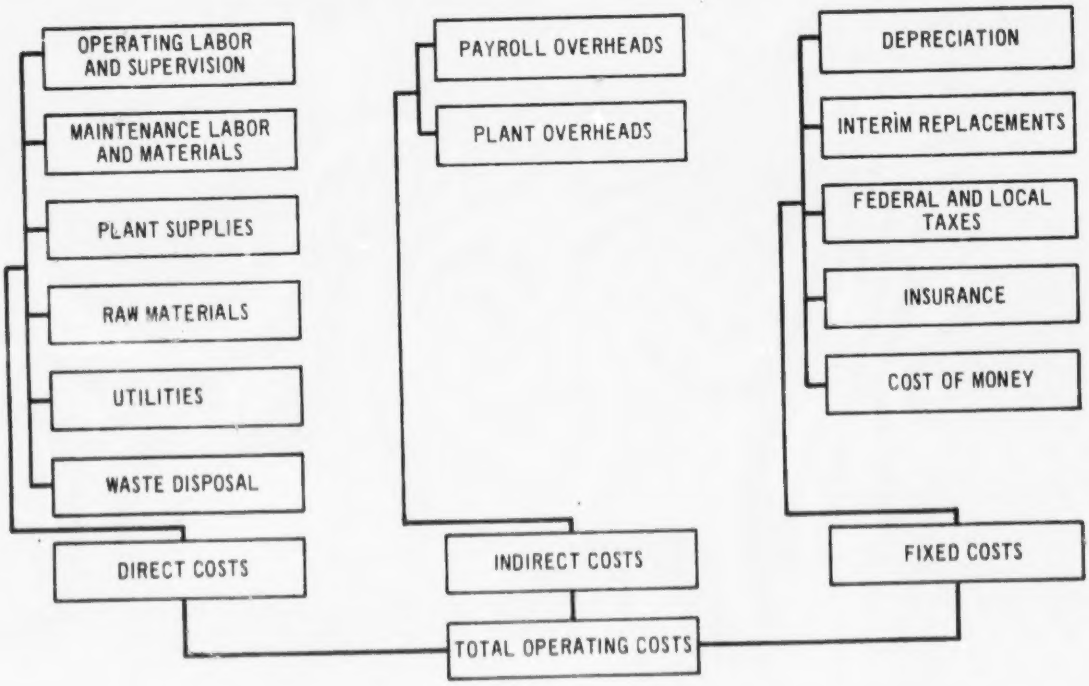
OPERATING LABOR AND SUPERVISION
MAINTENANCE LABOR AND MATERIALS
PLANT SUPPLIES
RAW MATERIALS
UTILITIES
WASTE DISPOSAL
PAYROLL OVERHEADS
PLANT OVERHEADS
DEPRECIATION
INTERIM REPLACEMENTS
FEDERAL AND LOCAL TAXES
INSURANCE
COST OF MONEY
DIRECT COSTS
INDIRECT COSTS
FIXED COSTS
TOTAL OPERATING COSTS

Figure 3. Relationship between factors included in the total operating costs.

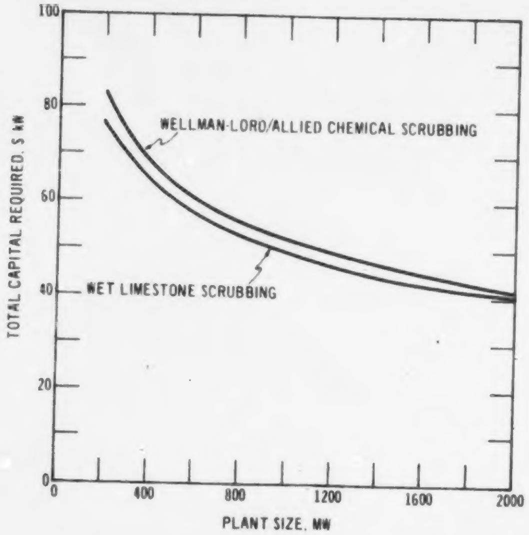

Figure 4. Estimated capital required to install scrubbing on existing utilities to meet emission limit of 1.2 lb SO_2/MMBtu of fuel burned by the plant.

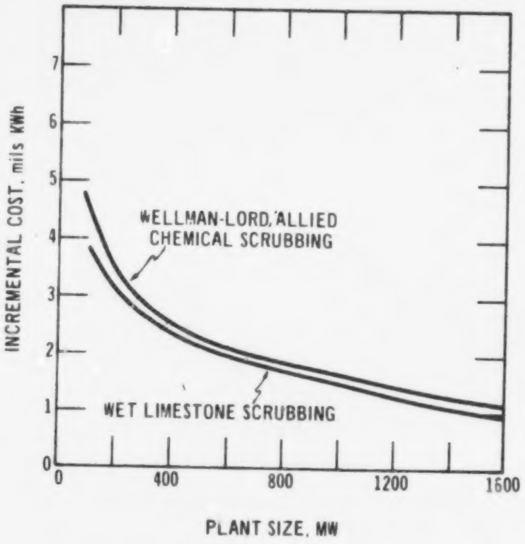

Figure 5. Estimated incremental cost of electricity for existing utilities to meet emission standard of 1.2 lb SO_2/MMBtu of fuel burned by the plant.

SOLID WASTE CONTROL TECHNOLOGY AND ITS APPLICATION

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ABSTRACT

Both the quantities and composition of today's solid waste are changing radically not because of consumer attitudes, but as a result of the strict application of pollution abatement programs. Industries are producing sludges and slurries as a result of in-house abatement practices. Typically, these waste contain high moisture contents. The waste products which have been removed from air and water and the water content as presented for disposal are requiring a reassessment of the present technology of disposal and processing. The technologies in existance have always been allowed minor emissions as a tolerable level of operation. The emerging abatement programs combined with the potential hazards represented by the industrial discharges, increasing volumes and exotic sources makes the zero pollutant discharge criteria appear difficult if not impossible to attain. Obviously, increased sophistication will be required of our disposal techniques or some reasonable limitation of discharge must be established. The costs attributed to the control of solid waste can best be described as a complex interrelationship of costs derived from the enforcement of air and water abatement programs. The costs are rising at an alarming rate. The utilization of new and sophisticated technologies may do little to relieve the projected cost burden.

INTRODUCTION

The control technology for solid waste management was represented by the most simplistic of solutions until the early 1960's. The open dump, a few incinerators and a handfull of composting operations represented the extent of the technology offered. In fact, until the passage of the Solid Waste Management Act of 1965, most of the disposal technology was based on the control of large volumes of mixed waste from every conceivable source.

In most municipalities the problem was one of logistics. The number of stops requiring collection, the required truck size for most economical operation and the economy of volume reduction through incineration or the best location to dump the waste with least effort and least citizen objection were the problems faced by almost every community of any size.

The Solid Waste Management Act of 1965 supported investigation and demonstration of new concepts and technologies. The federal act expressed the first real concern for the environment in addition to the logistic problems indicated. In response, both private enterprise and public works groups intensified their efforts toward the development of new equipment and refined management methods.

STATE ACTIVITIES

Probably the greatest change in the control of solid waste came about as a result of the Act's support of state programs. Most states redirected their thinking, accepting a role of environmental planning for better waste management in lieu of the former "Fire-fighting" concept (acting only during utmost emergency at the behest of citizen outcry).

Open dumps were outlawed on the basis of the obvious presence of rodents and insects and the ever present air pollution by decomposition and fires. Some incinerators were closed as their operation succeeded in reducing volume at the cost of local air quality. Many collection systems were upgraded to include compaction type vehicles with closed bodies to prevent litter, odor and provide increased tonnage capacity.

The States interests in most cases resulted in new legislation providing higher standards of operation, permit procedures and enforcement activities. These new programs emphasized the environmental aspects of controlling solid waste and most have relied heavily upon the related legislation which limits the emissions into the air and waters of the State.

Air and water pollution control practices were developed around natural movement of air and water and the biological and chemical changes taking place within the element. Solid waste management principles recognizes those same changes as evidenced by the pollution of air and water. The location of pollution is a direct result of its origin, but if the production source is solid waste, the location may occur without relation to its real origin. The movement is ordained by man, and unrelated to wind or stream direction, velocity or volume. Because of this difference in manners of movement, State solid waste regulations rely heavily upon the control of pollution resulting from waste after its man-directed movement. Air and water pollutant limitations are the most frequently identified solid waste control regulations.

POLLUTION CONTROL AND SOLID WASTE

As an example, sanitary landfill rules are replete with statements limiting the impact of air and water bourne emissions from the facility. In most every instance, the regulations require that no adverse effects may occur, or at the very least that those effects noted should not limit adjacent aquifer uses. The results of these obvious concerns has been the development of concepts as encapsulation and/or treatment of effluents from sanitary landfill sites. The complete containment of separation of waste for all time is much more difficult to accomplish than it may first appear. Storm water, ground water and moisture in wastes as delivered complicate the process considerably. The development of volatile acids and gases are the common results of anaerobic decomposition. In the presence of biodegradable materials, moisture in any form accelerates this action. The exclusion of all water is difficult if not impossible to accomplish, even if partially accomplished the elimination of water passage may be a true example of the cup that runneth over-eventially.

With the concern for containment comes the further consideration of the possible treatment of the escaping liquid. This liquid, leachate, reflects the waste characteristics within the fill and is present in quantities representing the additions received through groundwater and precipitation. The treatment of leachate can be accomplished as a part of community wastewater treatment. Under those conditions, the collected leachate is combined with sanitary sewerage for treatment at the municipal plant. As with the treatment of industrial waste sources the compatability of the municipal process and leachate is a most important consideration. Treatment plants can be upset by heavy concentrations of metal salts. The smaller the treatment plant, the greater the chance that leachate may be an incompatable addition.

The alternative to the municipal treatment system is on-site treatment, usually a facility requiring the addition of lime, settlement, acidification, and possibly chlorination before discharge to a nearby water course.

The result of either leachate treatment process is a sludge, which upon removal from the system must be deposited somewhere. The sludge solids are returned to fill in much the same manner as a filtrate or centrate is returned to the primary stage of the treatment plant. In truth, the process of leaching and treating may be repeated ad infinitum.

INCREASING COSTS

Both the provision of impermeable barriers in support of the encapsulation concept and the provision of leachate treatment to reduce the pollutional flow increase the costs of sanitary landfill greatly. Early estimates of typical landfill costs ranged from $1.25 to $1.75 a ton for well operated sanitary fills. Membranes and treatment on-site or in municipal facilities may indeed add $1.00 or more to each ton hauled. Costs are, of course, based on the quantity received or managed and great variations in overall cost are encountered as the quantities and exact site requirements are varied. Suffice to say that the added cost of water pollution control can easily increase operating costs by 100 percent or more.

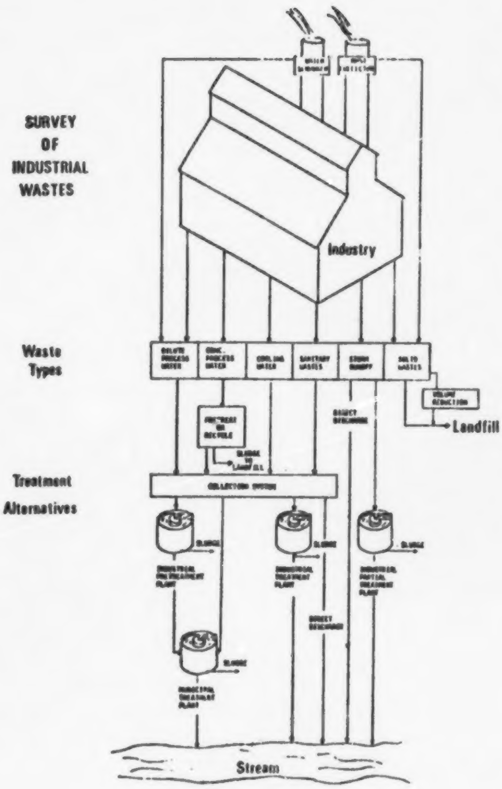
INCREASING QUANTITIES

The amount of waste received at a disposal site has been estimated by various persons for various purposes. Depending upon the reason for the estimate, it may include household waste, commercial waste, industrial waste, agricultural waste, mining or mineral wastes, or almost any waste identified. This statement is fact, except that many waste sources now appearing were not in existence as little as five years ago.

The impact of present day air and water pollution control legislation has created a new and somewhat unique waste product - pollution control sludges. These sludges, containing those materials which have previously been declared a pollutant, are quite different from the wastewater treatment plant sludges previously relegated to landfills. They, like the leachate previously described, contain concentrated quantities of potentially toxic materials - the reason for their removal from air or water.

SPECIAL WASTES

Not only does the presence of potentially toxic materials in concentrated quantities present a landfill disposal problem, but the presence of moisture in the sludges accelerates and supports anaerobic conditions in mixed fills in a manner which increases the volume and intensity of leaching. Increasing sludge solids content to approximately 50 to 60% will reduce the leaching potential or at the very least delay its occurrence. Unfortunately the costs of increasing the percentage of solids in sludges are not in direct proportion to the advantage gained. Increasing percentages of solids require increasing dollar expenditures for each increment of gain.


SURVEY
OF
INDUSTRIAL
WASTES
Industry
Waste Types
DILUTE PROCESS WATER
CONC. PROCESS WATER
COOLING WATER
SANITARY WASTES
STORM RUNOFF
SOLID WASTES
VOLUME REDUCTION
Landfill
DIRECT DISCHARGE
PRETREAT OR RECYCLE
SLUDGE TO LANDFILL
Treatment Alternatives
COLLECTION SYSTEM
SLUDGE
INDUSTRIAL PRETREATMENT PLANT
INDUSTRIAL TREATMENT PLANT
INDUSTRIAL PARTIAL TREATMENT PLANT
DIRECT DISCHARGE
MUNICIPAL TREATMENT PLANT
Stream

From "Pretreatment of Liquid Industrial Wastes"
L. Scully, Assistant Project Engineer
Roy F. Weston, Inc.

Thus, not only are greatly increased quantities of waste to be expected, the wastes are anticipated to be highly toxic and of marginal composition for the direct incorporation into a landfill using present standards.

It is also of interest to analyse the materials leached from the site. The industrial sludges have already been removed from water once. Most chemical reactions occurring during the removal are reversible and the landfill leachate may, therefore, resemble quite closely the industrial sludges placed in the fill if and when the leaching does occur.

Preparing sludges for proper disposal in a landfill, in many instances, may require an intermediate processing to reduce the possibility of a reconstitution of the pollution potential.

SPECIAL LANDFILLS

It has been suggested by some that special "industrial waste" landfills may be in order. Industrial sludge fills would be constructed in isolated areas where isolation and the high pH conditions required to retain the metal ions and toxic salts could be continually maintained. Locations where acceptable geology for such disposal sites may restrict this concept to use where ground water supplies already are unusable and the annual precipitation is minimal. The State of California has developed a landfill classification system which relies on such practices to safely dispose of hazardous materials. The precipitation evaporation relationships in the West may be of considerable value in such operations. In most of the nation, actual locations for such a facility can not avoid producing extraordinary total costs for transportation and disposal. In summary, the nations hazardous waste program may require sophisticated landfill sites with leachate collection systems combined with specialized transport methods to dispose of wastes - wastes which until recently have been unknown.

SPECIAL PROCESSES

Landfills are not the only treatment of solid wastes that will receive the brunt of increased sludge contributions. Although neither composting nor incineration is suited to the disposal of all sludge, both methods have been employed for that purpose in specific instances.

Composting with municipal sludges has been successfully demonstrated both with municipal solid waste and select materials such as wood chips. This process produces a soil conditioner of rather limited nutrative value. Some of the major concerns expressed are the same as those related to the land spreading of sludge, the concentration of heavy metals in the soil may occur. While trace metals can be valuable nutrients, excessive amounts of metal ions can be toxic to plants and animals. Industrial sludges may be compatible with land spreading and composting techniques, but each situation requires an examination with care and consideration. It is doubtdoubtful that landspreading of raw or composted industrial sludge will be accepted on any great scale.

Incineration of some sludges will reduce organic content or provide chemical combinations which through additions of heat may establish non-soluable residues. Where organic content can be reduced, the pollution potential may also be reduced, but not necessarily in direct proportion to the energy, effort and costs expended. It is doubtful that thermal processing methods will be extremely popular until such time as auxiliary fuel may be of greater availability. Municipal refuse as an auxiliary fuel source may be of value, however, the economics of utilizing refuse to process sludge are closely related to the total costs of municipal waste incineration.

The costs of incineration has been rising due to the interest in providing new installations with separation, salvage, automation, air and water emission controls. Whether the industrial sludge can economically incinerated may not be the question. Without chemical changes the sludge may be more acceptable when "diluted" by the total incineration residue and, therefore, incineration could become the method of choice.

NEW DIRECTIONS FOR CONTROL

The Clean Air Act and the Federal Water Pollution Control Act include provisions which require the separation of contaminents from air and water. Recent emphasis on the control of hazardous pollutants has increased the number of industries which are required to consider processes for solids removal usually in the form of sludges.

It may be that the concepts expressed herein are somewhat confusing and are exceptional examples of what may occur using present technology. I personally do not believe that they lack realism, for many of the instances have come to my attention through clients and fellow engineers.

The Illinois Pollution Control Board in recent action fined both the city and the industrial source. The Board indicated its intent to continue to fine both the system into which they were discharged. These and similar actions nationwide will alert municipalities to the acute problems of industry.

California has established a landfill rating system such that wastes of high toxicity can be disposed into secure sites with minimal risk to the environment.

Another state has embarked upon somewhat different industrial (guaranteed high pH) landfill concepts. In this instance, the State required that 330 pounds of waste per day containing .004 percent zinc on a dry weight basis with a potential for leaching less than 0.0165 pounds/day, to be disposed of in a special isolated landfill. The local landfill receiving 300 tons or more each day was felt to be an obviously dangerous disposal concept, as the volatile acids in the fill might chelate the zinc from the sludge (pH.10.5+).

Here, at a cost of thousands the industrial waste process produced 330 pounds a day of a waste that could be disposed of at a rate of less than $2.00 per ton only to discover that the true cost were 10 to 20 times greater - and the alternative was to scrap the plant and use a different process for production - and to date, none exist.

In another instance, a small oil reprocessing refinery (8 to 10,000,000 gallons/year) embarked upon a industrial waste water treatment program, only to find that the process was too costly to continue operation. Now those oils originally reclaimed and refined must find their way to disposal sites, incinerators or other less desirable locations. The problem was not solved - it spread and a valuable resource was lost forever. State and local officials are now desperately searching for methods of disposing of waste oils, some are even considering reprocessing refineries - as if the concept is new and unique.

A recent news release from an Eastern corporation indicates that the lead removal from the sludge left over from processing the 100 to 150 million gallons of waste automotive oil refined annually would yield approximately 1% lead equal to some of the low grade ores now mined commercially.

The corporation would like to contract for the removal of this lead content indicating that by itself it might not be a profit making venture, however, the prohibition of sludge in landfills, the serious threat of air pollution resulting from its incineration might justify the lead reclamation. A new industry or an elaboration of the existing oil reclamation industry may be in the offing.

SUMMARY AND RECOMMENDATIONS

As we approach the period in time when zero pollution discharges are to become a reality, a true concern for the total cost and total processing must be maintained. New and improved methods of returning used materials to the environment and a reasonable understanding of the realities of control must be established. We are seriously deficient in our analysis of the true costs of regulation and its impact upon our economy. The processes may be simple, but the implications are not.

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RADIOACTIVE WASTE GENERATION AND MANAGEMENT

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ABSTRACT

Radioactive wastes are produced at all steps in the nuclear fuel cycle. The difficult waste management problems are experienced at the power reactors and reprocessing plants where fission products must be separated from effluent streams and retained for ultimate disposal. It is at these points in the fuel cycle where the various techniques for waste management and control must be employed to prevent adverse impact upon the environment. For liquid radioactive waste processing, filtration, ion exchange, evaporation, and holdup for radioactive decay are the techniques most often utilized while filtration and holdup for radioactive decay are most frequently used to process gaseous streams. These processes have been effective either alone or in various combinations to reduce radioactive effluents from nuclear facilities to levels substantially below those levels existing naturally.

INTRODUCTION

The emphasis of this conference is on Water Pollution Control Technology Assessment. Yet the discussion of the management of radioactive wastes resulting from the use of uranium as a fuel source for power generation does not lend itself to the narrow category of liquid wastes. Radioactive wastes in liquid forms do occur, but control of these are best examined within the context of total waste management - air, solids and liquids - since all could have impacts on water pollution.

Before entering into a presentation of radioactive effluent control technology, particularly to a group that may not be too familiar with the nuclear fuel cycle and the sources of radioactivity resulting therefrom, a brief summary will be made to depict the processes over which control must be exercised. Emphasis will be placed upon the power reactors since these are the nuclear facilities proliferating at a relatively rapid rate throughout the country.

THE NUCLEAR FUEL CYCLE

Commercial power reactors currently in operation or under construction in the United States are fueled by slightly enriched uranium; that is, fuel in which the percentage of the uranium - 235 isotope in the uranium mixture is higher than the 0.7 percent found in nature. The uranium ore from the mines is processed at the uranium mills to recover a semirefined product consisting of uranium oxide, U_3O_8. This product from the mill, called "yellowcake" is the feed material for conversion to gaseous uranium hexafluoride, UF_6, required by the gaseous diffusion process. The gaseous diffusion process alters the relative abundance of the isotopes in the mixture by separating the feed material into two streams - one enriched in the lighter isotopes and the other depleted of the lighter isotopes.

In a power reactor, the uranium is in the form of uranium dioxide pellets sealed within zircaloy tubing. Thousands of these fuel loaded tubes make up the reactor core.

Up to this point in the fuel cycle all of the radioactive waste products are those which had existed in nature - no new radioactive material has been created. However, in the reactor, the fuel undergoes fission creating lighter fission fragments, many of which are radioactive, from the uranium. Additionally, neutron activation of materials surrounding the fuel such as impurities in the coolant, fuel cladding, and structural materials produces radioactive materials.

When the fuel is replaced, after perhaps three years exposure in the reactor, there is still a significant amount of uranium - 235 remaining in the so-called spent fuel elements; in addition, some fissionable plutonium isotopes have also been created by neutron absorption in the non-fissioning uranium - 238 isotope present in the fuel. These "spent" fuel elements contain a substantial value of unburned fuel and are transferred to reprocessing facilities for the recovery of these values. The recovered uranium is then re-cycled starting at the conversion to uranium hexafluoride and the plutonium is retained for future fabrication directly into fuel.

Typical reactor systems operating with the maximum design fission product levels in the coolant would only result in about 1/1000th of the fission product radioactivity escaping from the fuel. We should note here that this radioactivity is not released directly to the environment, but is contained within the reactor coolant system. Other systems are installed to remove as much of this radioactivity as possible so that only a small fraction of the radioactivity circulating with the coolant escapes to the environment.

In the fuel recovery process, the fission products which have been so carefully retained within the fuel element during its life in the reactor core are separated from the uranium and plutonium to permit reuse of the latter in new fuel. It is at this stage of the fuel cycle that long term management of radioactive wastes becomes especially important. One metric ton of uranium fuel will produce about 200 million kw-hr of electric power - roughly the annual consumption of 25,000 persons in the United States. Reprocessing this amount of spent fuel gives rise to about 0.4 to 0.8 cubic meters of high level liquid waste or about 0.04 cubic meters of solid waste. The typical reprocessing plant capacity is on the order of 1 to 5 metric tons of fuel per day. Figure 1 depicts the nuclear fuel cycle.

SOURCES OF RADIOACTIVITY

Mining, Milling, Enrichment and Fuel Fabrication

The mining of uranium ores is the starting point in the production of fuel for nuclear power plants. These ores contain oxides or uranium in relatively low concentrations, mixed or combined with other minerals. The radioisotopes associated with the uranium ores are the naturally-occurring decay products of uranium. The radioactive wastes resulting from mining are primarily those associated with airborne dust and the released radon and its daughter products. In deep pit mining, the concentration of these airborne contaminants is controlled by the volume of air used in ventilation. When airborne dusts are a problem the air may be filtered and in special cases, if necessary, the miners may use respirators to limit their exposure to radiation. For a large part of the uranium mined in the United States,

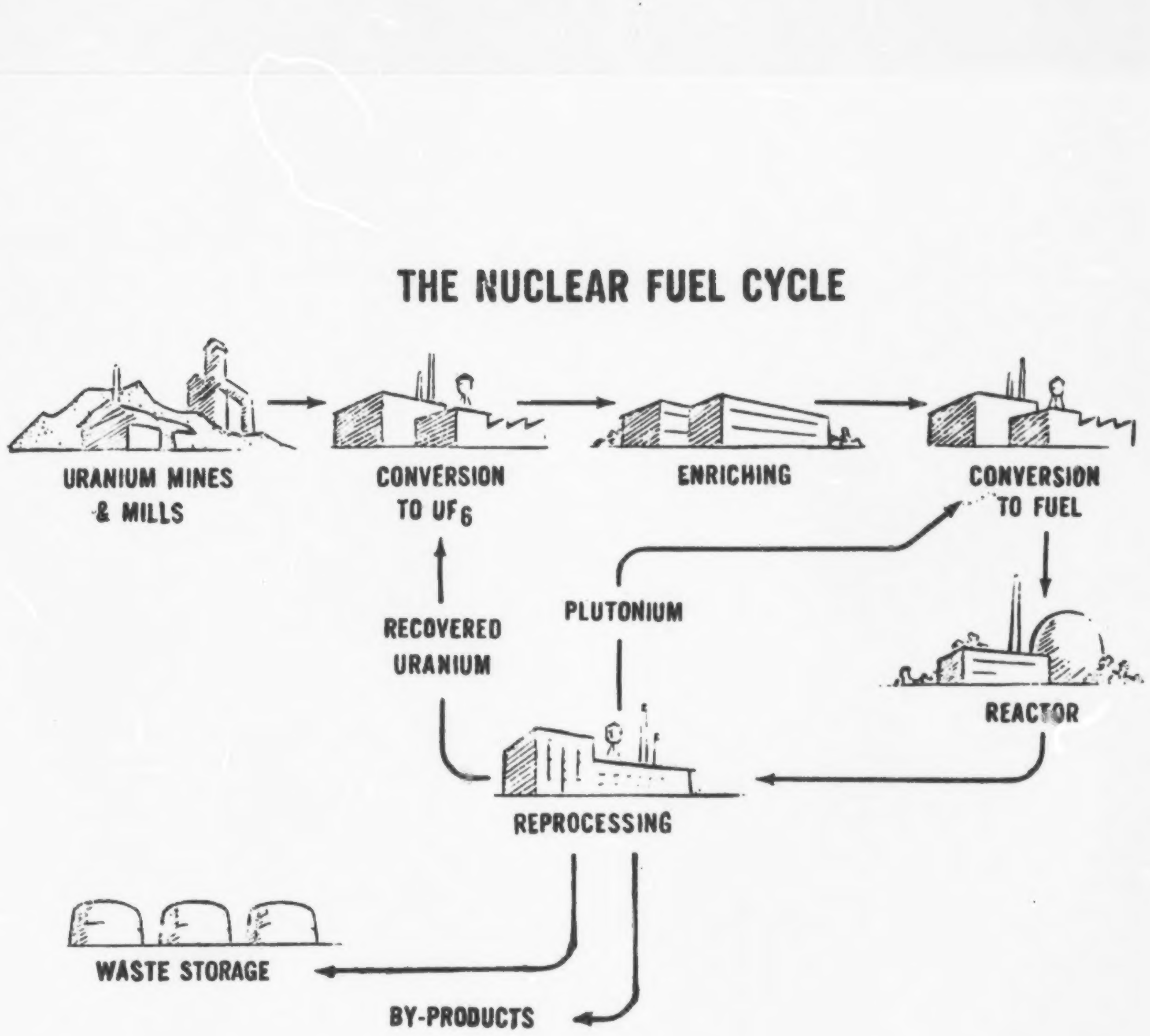
THE NUCLEAR FUEL CYCLE
URANIUM MINES & MILLS
CONVERSION TO UF$_6$
ENRICHING
CONVERSION TO FUEL
REACTOR
PLUTONIUM
RECOVERED URANIUM
REPROCESSING
WASTE STORAGE
BY-PRODUCTS

Figure 1. The Nuclear Fuel Cycle (From WASH 1250)

open pit mining techniques are employed, in which case the radon problem is virtually non-existent.

The next step in preparing the uranium for use in fuel fabrication is the milling and concentration of the oxide. The uranium-bearing ores are crushed into a relatively fine form in preparation for leaching of the uranium. Since the uranium is only a small fraction - generally less than 1% of this material - the bulk of it remains as tailings for disposal as both solid and slurry wastes. The quantities of uranium oxides and of radium sulphate in these wastes are limited purposely since they are valuable. The radioactivity of the uranium is not a controlling factor at this stage - much more important is its chemical toxicity. The solid and slurry wastes are often deposited on a tailings pile where leaching of radium and escape of radon can occur. Recent trends are toward drying these wastes and stabilizing them with landscaping after covering them with soil thus minimizing their movement in the environment.

Uranium oxide is converted next into uranium hexafluoride, which can be easily maintained in a gaseous state as required by the gaseous diffusion process. Uranium from the reprocessing of spent reactor fuels are also recycled through the enrichment plant. Gaseous wastes from the chemical conversion step are filtered prior to release to the environment.

After enrichment the uranium hexafluoride is converted again to an oxide for use in the fabrication of reactor fuel elements. Fuel fabrication gives rise to various types of liquid, gaseous and solid wastes which are slightly contaminated with uranium, its daughter products and plutonium (when recycled materials are used).

Nuclear Power Plants

In a nuclear power plant, radioactive materials are formed by the nuclear process. The principal radioactive materials formed are the fission products. The quantity of fission products formed is small in terms of mass; in a large power plant this will amount to only several kilograms each day. The shorter-lived radionuclides contribute substantially to the total inventory of radioactivity in terms of curies. After a few weeks of operation of a power reactor, the fission product inventory might be about 40% of what would exist after a two year operating period. More importantly, as will be explained later, all but a very small fraction of the radioactive fission products remain confined within the fuel element where they were formed. The quantity of fission products within reactor fuel elements will depend upon: (1) the power level of the reactor, (2) fuel residence time in the reactor, (3) elapsed time from reactor shutdown.

Structural materials used in the reactor core and the components which confine the reactor coolant will corrode and erode slightly with time - but enough to create fine particulates identified broadly as "corrosion products". These corrosion products, along with other impurities dissolved in the coolant, circulate through the core of the reactor, where neutron bombardment causes them to become radioactive. The quantities of radioactive materials so formed are small compared with the fission products, and consist commonly of radioisotopes of elements such as iron, chronium, cobalt and manganese. Some type reactors use boron in the reactor core and core coolant to control the fission process. Neutron absorption by boron leads to the formation of tritium, a radioactive isotope of hydrogen. Tritium formation also occurs as a result if water is the coolant, or neutron absorption by deuterium - a natural isotope of hydrogen found in ordinary water.

Although the kinds of radioactive wastes produced as by-products of the fission process are basically the same for all uranium fueled reactors the characteristics of the effluents from plants can vary appreciably, depending upon the reactor coolant and steam cycles used. The radioisotopes in the effluent streams in turn influence strongly the design of particular waste treatment systems.

Objectives in nuclear power plant radwaste system design are to process and recycle waste streams so as to minimize both the volume and the radioactivity levels of the effluents wherever practical.

WASTE MANAGEMENT TECHNIQUES

During the course of operation of a power reactor, small amounts of the radioactive fission products contained within the fuel elements will escape through defects which cannot be completely eliminated in the canning surrounding the fuel material. Because of this, power reactors are designed to operate with a certain amount of radioactivity circulating with the reactor coolant as a result of operating with a small fraction of defective fuel. The amount released, however, is a small fraction of the radioactive fission products contained in the fuel elements. The released fission products initially appear as dissolved material in the reactor coolant while the activation (corrosion) products may appear as dissolved or suspended material.

Waste management techniques now in use for gaseous wastes are delay and decay, filtration, and low temperature adsorption on charcoal. Delay and decay refer to the storage of waste for a long enough time to decrease the associated treatment problem by permitting some radioactivity to decay before release. The usefulness of this technique as a means for reducing activity levels in gaseous wastes depends on the half-lives of the isotopes present. Gases are then filtered to remove particulate material and released through stacks to the atmosphere. Specially treated charcoal filter beds may be used to remove iodine. Low temperature adsorption is useful in providing delay and decay of short-lived noble gases.

Liquid waste management systems employ four basic treatment techniques to reduce levels of radioactivity. These are delay and decay; filtration, evaporation, and demineralization. In the case of reactors in which once-through cooling systems are used, a final reduction in liquid radionuclide concentrations is achieved by dilution of the wastes in the condenser cooling water.

The delay and decay technique used in the treatment of liquid waste is identical in principle to that for gaseous waste, although in practice little reduction in liquid radioactivity levels is achieved. Radionuclides in liquid radioactive wastes tend to have relatively long half-lives in comparison to the practicably achievable delay time in the plant. The relatively long delay time needed to achieve an appreciable reduction in liquid waste radioactivity levels would result in an excessive inventory of waste liquid onsite. It is estimated that it would take about 40 days to reduce the radioactivity levels of typical liquid waste by a factor of about five.

Filtration is a useful treatment of liquid waste streams which contain suspended particulate contaminants. Filtration, however, is employed usually in conjunction with other methods of treatment either as a pretreatment to remove particulate material which could interfere with or reduce the efficiency of a subsequent process or as a final barrier to prevent the gross release of activity resulting from process failure such as the release of resin fines from an ion exchanger. Various types of filters are used including sand filters, activated carbon, precoat, fibrous and metallic filters.

Evaporation separates water from nonvolatile dissolved and suspended radioactive wastes. This process concentrates and reduces the volume of the wastes and reduces the activity level of the effluent. The efficiency of this technique for radioactive waste treatment can vary widely depending on the characteristics of the radioactive materials involved. A reduction of 100 to 1000 in the activity level can be achieved, depending on the design of the evaporator. If volatile radioactive materials such as iodine or ruthenium are present, the overall reduction in activity level may be substantially less. Tritium, of course, being incorporated as water, would be unaffected. Evaporation is a common method of treatment of liquid wastes because streams having a relatively high content of dissolved solids can be accommodated. It is, consequently, a suitable process for use in conjunction with subsequent ion exchange treatment of the distillate from evaporators.

The efficiency of demineralizers (ion-exchangers) in the treatment of waste streams depends on the type, composition and concentration of waste liquid, the type of exchange resin, radionuclides present, and operating procedures. The reduction achieved in activity levels may be as low as 2 or as high as 10^5. Only wastes containing relatively low dissolved and suspended solids can be processed by ion exchange because otherwise bed depletion occurs rapidly. Suspended solids tend to clog an ion exchanger and reduce its operating efficiency. Thus, the use of ion exchange treatment is restricted to radioactive wastes with low total dissolved solids and low suspended solids. Filtration is always used as a pretreatment.

Boiling Water Reactors (BWR)

One of the two types of light water reactors being marketed and operated on a large scale presently is the boiling water reactor (BWR). In this type reactor (Figure 2), water is circulated through the reactor core where it is heated to boiling. A pressure is maintained on the boiling coolant so that the boiling temperature is elevated resulting in high-pressure, high-temperature steam which is used to drive a turbogenerator. The exhaust from the turbine is then cooled in a condenser and recirculated through the reactor core. Water is used to cool the condenser. The basic operation of such a plant, apart from the nature of the heat source, is similar to that of a fossil-fueled installation.

To maintain high thermal efficiency, turbines are operated at a low back pressure generally on the order of 1 to 2 inches of mercury. Hence, the low pressure end seal for the turbine shaft is supplied with high pressure steam to prevent air inleakage. The steam to the seal leaks both into the low pressure end of the turbine and to the atmosphere. Air inleakage, however, is not completely eliminated from the system, therefore, an air removal system continually removes non-condensible gases from the condenser. This includes any gaseous fission products leaking into the coolant from the fuel.

Other sources of radioactive effluents in BWR's are reactor containment purging, radwaste treatment system and various other system tank vents.

A typical early BWR off-gas system is shown in Figure 3. Non-condensible gases are drawn from the main condenser through steam jet air ejectors and condensers into a delay line, where they are retained typically for 30 minutes depending upon design details. After this delay time, the gases pass through a high efficiency particulate filter and are discharged through the stack. The stack is usually about 300 feet high, although its actual height is influenced by site topography. The gaseous wastes consist principally of the isotopes of the noble fission products krypton and xenon and some activation products of oxygen and nitrogen. The isotopic composition of the krypton and xenon depends on the radiation characteristics of the reactor fuel and on the age of the mixture at the time of release, because many isotopes of krypton and xenon have a relatively short half-life. Radioactive particulates appear in the gaseous waste as a result of the decay of noble gas precursors and isotopes of some of the more volatile elements, such as iodines, will be carried over as a gas.

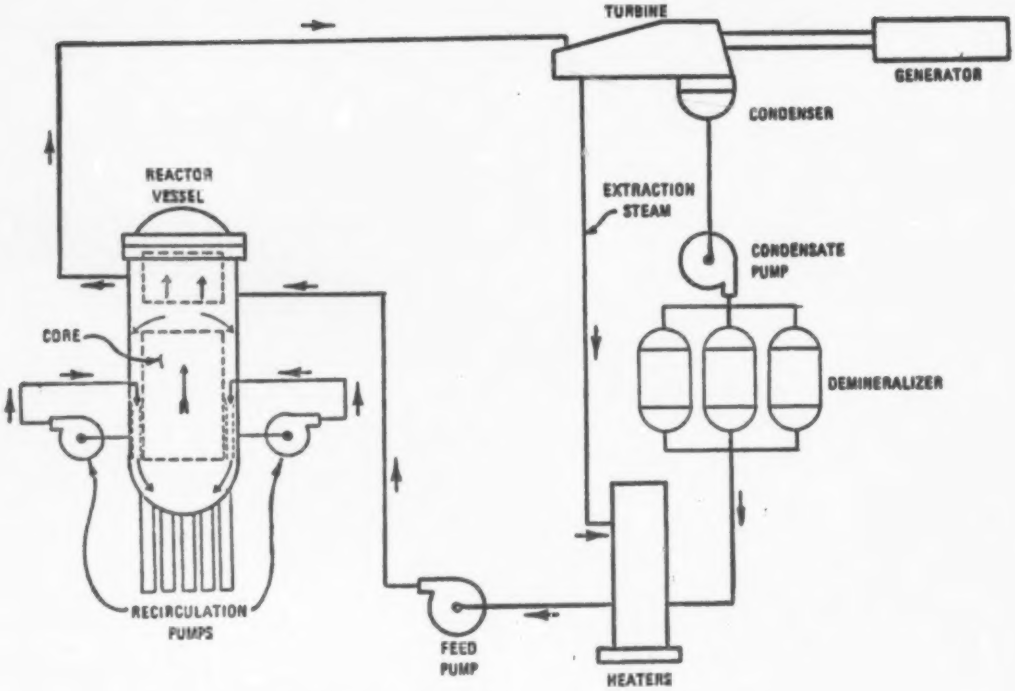
TURBINE
GENERATOR
CONDENSER
REACTOR VESSEL
EXTRACTION STEAM
CONDENSATE PUMP
CORE
DEMINERALIZER
RECIRCULATION PUMPS
FEED PUMP
HEATERS

Figure 2. Boiling Water Reactor System

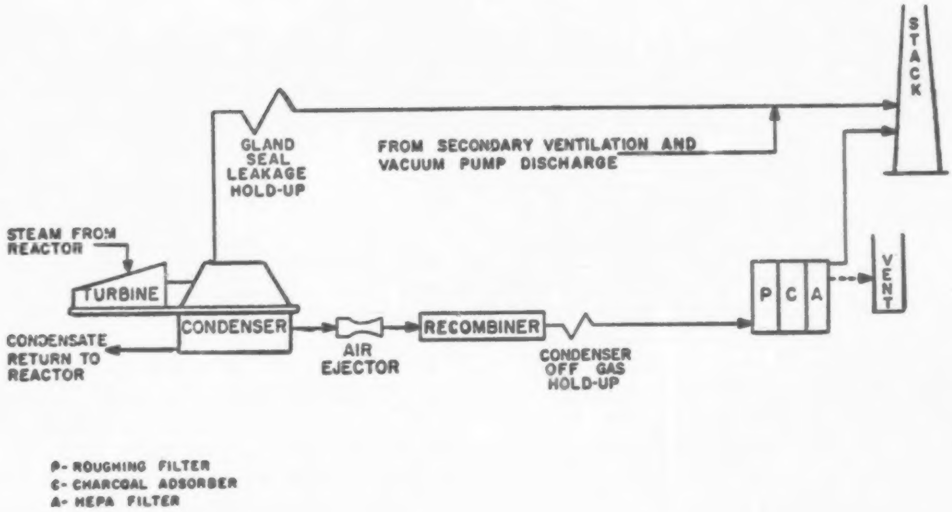
STACK
GLAND SEAL LEAKAGE HOLD-UP
FROM SECONDARY VENTILATION AND VACUUM PUMP DISCHARGE
STEAM FROM REACTOR
TURBINE
CONDENSER
CONDENSATE RETURN TO REACTOR
AIR EJECTOR
RECOMBINER
CONDENSER OFF GAS HOLD-UP
P
C
A
VENT
P- ROUGHING FILTER
C- CHARCOAL ADSORBER
A- HEPA FILTER

Figure 3. BWR Gaseous Waste System (From WASH 1250)

Table 1 shows the typical mixture of BWR off-gases after a 30 minute delay. Note that much of the activity release is represented by nuclides with relatively short half-lives.

In the latest BWR designs, provisions are being made to greatly reduce the discharge of these short half-lives.

In the latest BWR designs, provisions are being made to greatly reduce the discharge of these short-lived noble gases. This is accomplished through use of charcoal beds (Figure 4) to delay the noble gases for a considerably longer time to permit substantial radioactive decay. This has little influence on release of krypton 85 at the reactor site since this radionuclide has a half-life of about 10 years, but its contribution radiation in the vicinity of the plant is negligible. Table 2 shows the typical releases from the latest BWR off-gas systems.

A typical BWR liquid radwaste processing system is shown in Figure 5. The unique feature of this system is the segregation of wastes by chemical and physical properties. Influent is collected and processed according to its classification as high-purity (equipment drains), low-purity (floor drains), and chemical or laundry wastes. Contents of equipment drains are filtered and demineralized, and can then be either used again in the plant, or measured and discharged. Plant floor drains, chemical wastes and laundry wastes are filtered and discharged from the plant. Since the laundry wastes tend to foul filtering media, they are processed separately through their own filter.

The constituents of radioactive liquid waste from a BWR are activated corrosion products, and fission products. The fission product levels are attributable to traces of uranium that may be found on the outer surfaces of the fuel cladding and to leakage from fuel elements through cladding defects. The relative contribution of leaking fuel elements depends, of course, directly upon the number of leaking fuel rods and the severity of the breaks.

The major sources of solid radioactive wastes at BWRs are contaminated filters, precoat filter media and spent demineralizer resins. These wastes are first centrifuged to remove excess water then solidified with concrete in 55 gallon steel drums. The drums are normally stored three to six months before shipped offsite for permanent burial. Several hundred are shipped each year from a typical BWR installation.

Pressurized Water Reactor (PWR)

In a pressurized water reactor, PWR (Figure 6), the reactor coolant is not allowed to boil. Instead, the high temperature, high pressure liquid is pumped to a steam generator where heat is transferred to water contained in a separate circulation loop. The water in this sytem is allowed to boil producing the required motive steam for the turbo-generator. Since the entire reactor coolant system is maintained at high pressure, there is no requirement to continually remove non-condensible gases from the coolant and consequently the residence time of dissolved gases in the coolant is considerably longer than in a BWR.

Gases are removed from the PWR coolant by reducing the temperature of a side stream and relieving the pressure. The non-condensible gases relieved are collected in a vent header and led to the gaseous waste processing system.

A typical early PWR gaseous radwaste system is shown in Figure 7. The waste gases from various sources are collected in a vent header and discharged by a waste-gas compressor into one of several decay tanks. When a tank reaches a set pressure and activity level it is isolated and a second tank is placed in service. Gas is held for decay for from one to two months before being discharged through a filter to

TABLE 1. TYPICAL BWR OFF-GAS MIXTURE USING 30 MINUTE HOLDUP*

Nuclide	Half-Life Range	Release Rate
Kr-89 Xe-137 Xe-135m Xe-138	3.2 to 17 minutes	35,790 μCi/sec
Kr-87 Kr-83m Kr-88 Kr-85m	1.3 to 4.4 hours	41,430 μCi/sec
Xe-135	9.2 hours	17,550 μCi/sec
Xe-133m Xe-133 Xe-131m	2.3 to 12 days	5,220 μCi/sec
Kr-85	10.4 years	10 μCi/sec
	TOTAL	100,000 μCi/sec

*Adapted from information published by J.M. Smith, November, 1960.

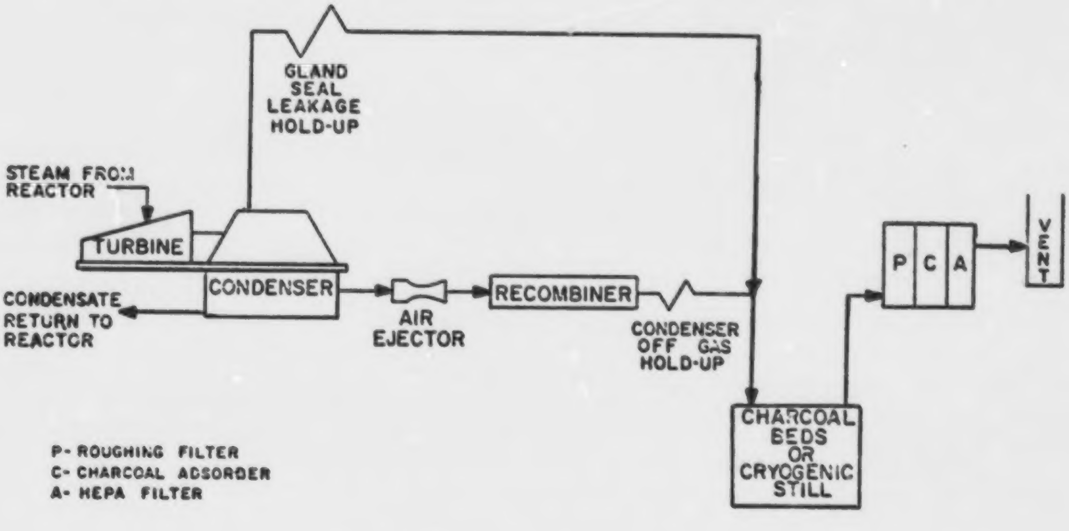
GLAND SEAL LEAKAGE HOLD-UP
STEAM FROM REACTOR
TURBINE
CONDENSER
CONDENSATE RETURN TO REACTOR
AIR EJECTOR
RECOMBINER
CONDENSER OFF GAS HOLD-UP
CHARCOAL BEDS OR CRYOGENIC STILL
P
C
A
VENT
P- ROUGHING FILTER
C- CHARCOAL ADSORBER
A- HEPA FILTER

Figure 4. Modified BWR Gaseous Waste System

TABLE 2. TYPICAL BWR OFF-GAS MIXTURE USING CHARCOAL DELAY SYSTEM*

	Nuclide	Half-Life Range	Release Rate
	Kr-87 Kr-83m Kr-88 Kr-85m	1.3 to 4.4 hours	179 μCi/sec
	Xe-133m Xe-133 Xe-131m	2.3 to 12 days	573 μCi/sec
Kr-84	Kr-85	10.4 years	10 μCi/sec
		TOTAL	762 μCi/sec

* Assumes about 50 tons of charcoal at 70F yielding 24 hour holdup for Kr and 16.6 days for Xe. Gas to holdup system same as for Table 1.

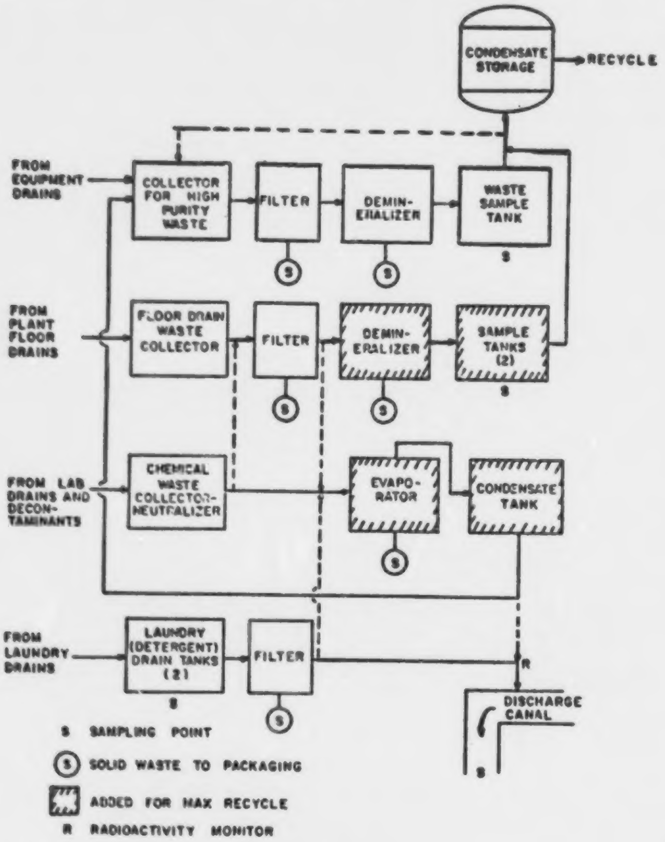
CONDENSATE STORAGE
RECYCLE
FROM EQUIPMENT DRAINS
COLLECTOR FOR HIGH PURITY WASTE
FILTER
DEMIN-ERALIZER
WASTE SAMPLE TANK
S
FROM PLANT FLOOR DRAINS
FLOOR DRAIN WASTE COLLECTOR
FILTER
DEMIN-ERALIZER
SAMPLE TANKS (2)
S
FROM LAB DRAINS AND DECON-TAMINANTS
CHEMICAL WASTE COLLECTOR-NEUTRALIZER
EVAPO-RATOR
CONDENSATE TANK
FROM LAUNDRY DRAINS
LAUNDRY (DETERGENT) DRAIN TANKS (2)
S
FILTER
R
DISCHARGE CANAL
S
S SAMPLING POINT
Ⓢ SOLID WASTE TO PACKAGING
▨ ADDED FOR MAX RECYCLE
R RADIOACTIVITY MONITOR

Figure 5. BWR Liquid Waste System (From WASH 1250)

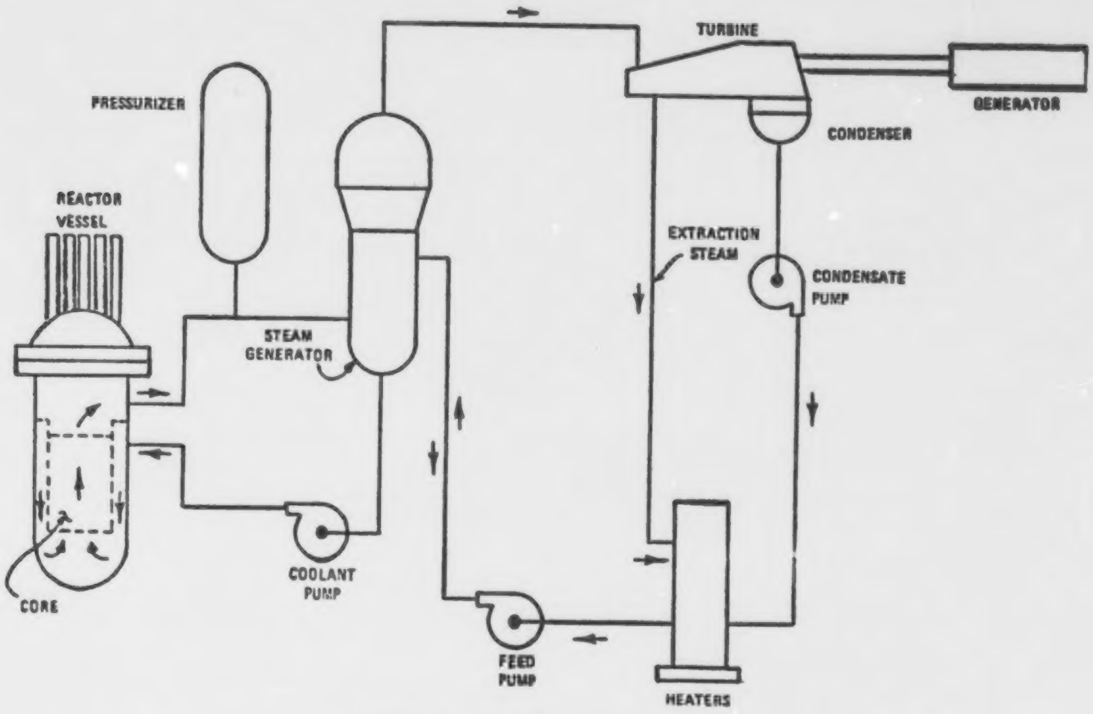
TURBINE
GENERATOR
PRESSURIZER
CONDENSER
REACTOR VESSEL
EXTRACTION STEAM
CONDENSATE PUMP
STEAM GENERATOR
COOLANT PUMP
CORE
FEED PUMP
HEATERS

Figure 6. PWR Reactor System

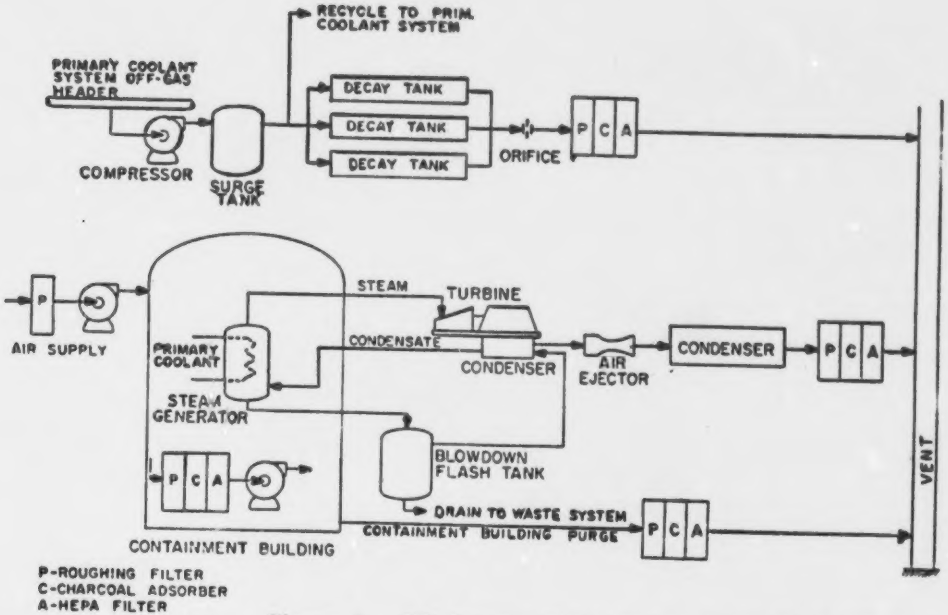
RECYCLE TO PRIM. COOLANT SYSTEM
PRIMARY COOLANT SYSTEM OFF-GAS HEADER
DECAY TANK
DECAY TANK
DECAY TANK
P
C
A
ORIFICE
COMPRESSOR
SURGE TANK
P
AIR SUPPLY
STEAM
TURBINE
CONDENSATE
PRIMARY COOLANT
CONDENSER
AIR EJECTOR
CONDENSER
P
C
A
STEAM GENERATOR
BLOWDOWN FLASH TANK
VENT
P
C
A
DRAIN TO WASTE SYSTEM
CONTAINMENT BUILDING PURGE
P
C
A
CONTAINMENT BUILDING
P-ROUGHING FILTER
C-CHARCOAL ADSORBER
A-HEPA FILTER

Figure 7. PWR Gaseous Waste System (From WASH 1250)

the environment from a building vent. Since these gaseous wastes are small in quantity and contain minimal activity, dispersal from an elevated stack is not necessary.

In the newer systems, the decay tanks have been replaced by charcoal delay beds resulting in significantly longer delay times. The newer systems also process the effluent from the condenser air removal system to delay any radioactive gases which might leak from the reactor coolant to the steam system at the steam generators. Table 3 shows typical PWR gaseous releases.

A typical PWR liquid radwaste system is shown in Figure 8. Wastes from various sources are collected in separate tanks and, when ready for processing, are discharged to the waste-holdup tank. This tank serves primarily as a batching tank for the waste evaporator. The distillate from the evaporation process is condensed and stored in a condensate storage tank before discharge from the plant. The concentrates are collected and stored for processing through the solid radwaste system.

Wastes which consist primarily of reactor coolant, are collected in holdup tanks. After filtration and demineralization of these wastes the boric acid evaporator serves primarily to recover boric acid and primary grade water. The boric acid evaporator condensate, after being filtered and demineralized, can be recycled to the primary coolant make-up tank or measured and released to the discharge canal.

Solid radioactive wastes from a PWR, although they may differ somewhat from those collected in a BWR are generally handled in the same manner. That is, by encasing or solidifying with concrete in steel drums which are then buried.

EVALUATION OF CONTROL TECHNOLOGY

Previous sections of this paper have briefly touched upon the sources of radioactive effluents and the basic control methods used to minimize the amounts of these releases to the environment. However, we have said little about the ability of these control methods to remove and minimize. Unfortunately, there is relatively meager data regarding the performance of such systems and what little data that does exist is frequently contradictory. For example, an examination* of operating data for several pressurized water reactors revealed overall decontamination factors for liquid wastes (defined as the ratio between the activity that would have been released if there were no waste processing and the activity actually released) which varied from less than 200 to more than 250,000. Even more disconcerting, however, is the fact that the low value was obtained from a plant which became operational nearly eight years later than that which resulted in the highest value of decontamination. This study was done in 1972. Today, the AEC requires more detailed reporting of the isotopic content of wastes discharged. Hopefully, this will yield some data which will be useful in predicting system performance under various operating conditions.

The regulations governing the quantities of radioactivity in reactor effluents allow nuclear power plants to contribute, at most, an exposure increase to any individual only a few percent above that which the individual might get due to normal background. (These backgrounds vary more than a few percent from location to location). The USAEC regulations require that nuclear power plants be designed, constructed and

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* De Agazio, A.W. "Fact and Fiction About Waste Disposal Systems", Presented at the American Nuclear Society Meeting, Las Vegas, Nevada. June 18 - 22, 1972.

TABLE 3. TYPICAL PWR GASEOUS RELEASE*

Nuclide	Release, Ci/year
Kr-85m	3.6
Kr-85	285
Kr-87	2
Kr-88	6
Xe-131m	11.6
Xe-133m	2.6
Xe-133	158
Xe-135m	1.2
Xe-135	9.2
Xe-138	1.2
TOTAL	480 curies/year

*Assumes charcoal holdup system providing about 3.5 days Krypton delay and 67 Xenon delay; 7 tons charcoal at 70F.

operated so as to keep levels of radioactive materials in effluents as low as practicably achievable. Further, to assure that such releases are as low as practicable, each license authorizing reactor operation includes technical specifications which govern the release of radioactive effluents. Currently, most specifications typically limit the average annual release of radioactivity in liquid effluents to 5 curies, excluding tritium although these specifications are flexible and allow for periods of higher than average release due to equipment malfunction. Table 4 summarizes the mixed fission product and activation product discharge in liquid effluents by operating reactors for the years 1970 to 1973. This table demonstrates that the technology exists to control radioactive releases in liquid effluents to very low values. Separate pathway analysis for exposure of man and other living organisms to these effluents indicate that the radiation impact to the biosphere is acceptable and commensurate with the benefits derived from the availability of electric power.

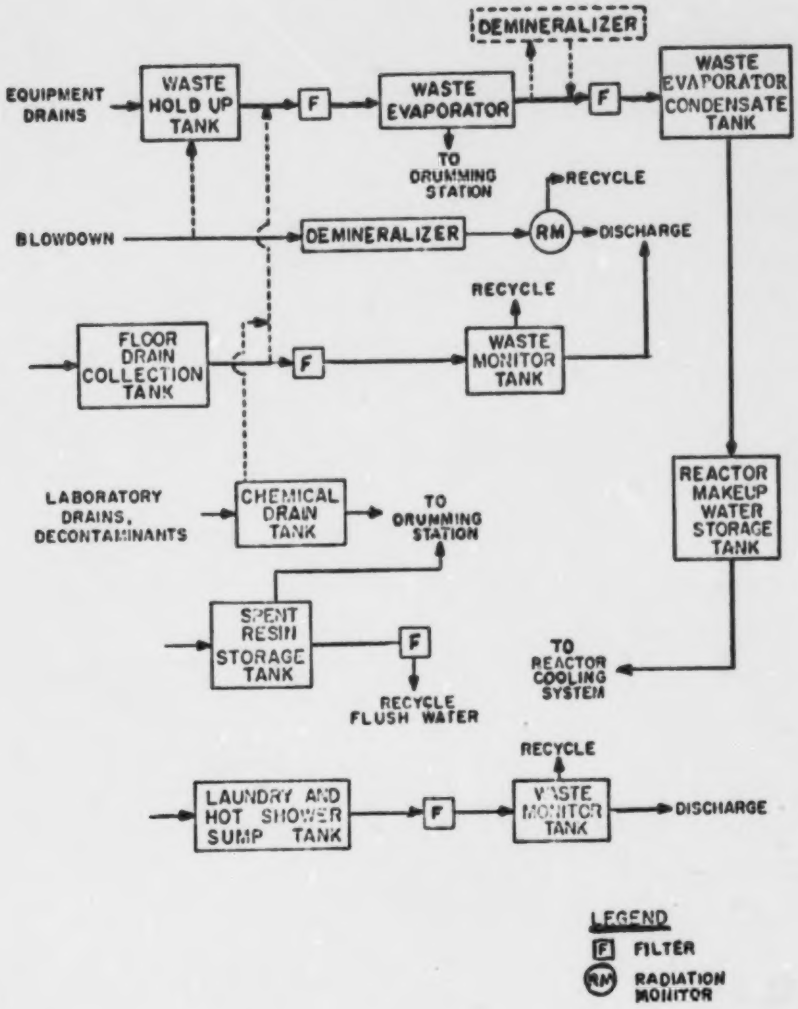
DEMINERALIZER
EQUIPMENT DRAINS
WASTE HOLD UP TANK
F
WASTE EVAPORATOR
F
WASTE EVAPORATOR CONDENSATE TANK
TO DRUMMING STATION
RECYCLE
BLOWDOWN
DEMINERALIZER
RM
DISCHARGE
RECYCLE
FLOOR DRAIN COLLECTION TANK
F
WASTE MONITOR TANK
REACTOR MAKEUP WATER STORAGE TANK
LABORATORY DRAINS, DECONTAMINANTS
CHEMICAL DRAIN TANK
TO DRUMMING STATION
SPENT RESIN STORAGE TANK
F
RECYCLE FLUSH WATER
TO REACTOR COOLING SYSTEM
RECYCLE
LAUNDRY AND HOT SHOWER SUMP TANK
F
WASTE MONITOR TANK
DISCHARGE
LEGEND
F FILTER
RM RADIATION MONITOR

Figure 8. PWR Liquid Waste System (From WASH 1250)

TABLE 4. LIQUID EFFLUENT COMPARISON BY YEAR

Mixed Fission and Activation Products

Curies

Facility	1970	1971	1972
Boiling Water Reactors			
Oyster Creek	18.5	12.1	10.0
Nine Mile Point	28.0	32.2	34.6
Millstone 1	-	19.7	51.5
Dresden 1	8.2	6.2	6.75
Dresden 2, 3	-	23.2	22.1
LaCrosse	6.4	17.1	48.5
Monticello	-	0.01	2.90×10^{-6}
Big Rock Point	4.7	3.5	1.09
Humboldt Bay	2.4	1.8	1.4
*Pilgrim	-	-	1.45
Quad Cities 1,2	-	-	2.41
*Vermont Yankee	-	-	None
Pressurized Water Reactors			
*Maine Yankee	-	-	0.0169
Palisades	-	-	6.81
Yankee	0.03	0.01	0.0206
Indian Point 1	7.8	81.1	25.4
R.E. Ginna	10	0.96	0.375
Connecticut Yankee	6.7	5.9	4.78
H.B. Robinson	-	0.74	0.862
San Onofre	7.6	1.54	30.3
Point Beach 1,2	-	0.15	1.53
*Surry 1	-	-	0.0252
Nonwater Reactors			
Peach Bottom 1	0.006	0.007	0.0209
Fermi	-	0.01	0.222

*Plants operated less than 1 year.

HAZARDOUS WASTE MANAGEMENT

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ABSTRACT

A recent program conducted for the Office of Solid Waste Management Programs of the Environmental Protection Agency in response to Section 212 of the Resource Recovery Act of 1970 is summarized. The program dealt with the evaluation of the need for a system of national disposal sites, the technology required, the cost involved on a national scale, and policy options for implementation.

INTRODUCTION

Over the past three years, the Environmental Protection Agency has been involved in responding to Section 212 of the Resource Recovery Act of 1970. This section raised a number of questions which included the need for:

1. A list of materials that should be regarded as hazardous in the context of disposal;
2. An evaluation of current disposal methods;
3. Recommended methods for reduction, neutralization, recovery, or disposal;
4. Inventory of possible sites; and
5. An estimate of cost including the best means for equitable distribution of this burden.

Also in Section 212, the Congress defined hazardous wastes to include "... radioactive, toxic chemicals, biological and other wastes which may endanger public health and welfare." This rather terse definition leaves much to be desired from the standpoint of management and regulation of hazardous wastes.

Finally, the Congress asked for a report and a plan for the creation of a system of national disposal sites, apparently with the idea in mind that the Federal Government is itself a major producer of hazardous materials, e.g., chemical and biological warfare agents, obsolete munitions, etc.; and that overall, the problem was of such magnitude that a national approach was called for.

EPA's response to the mandate in Section 212 has gone forward to the Congress as a report(1) and the proposed Hazardous Waste Management Act of 1973. This paper summarizes some of the highlight findings associated with the study leading to the report to the Congress.

THE NATIONAL DISPOSAL SITES STUDY

At the outset, it is important to note that Section 212 is not the only recent Congressional reference to hazardous materials. For example, the Federal Water Pollution Control Act Amendments of 1972 contain Section 307 dealing with toxic and pretreatment effluent standards and Section 311 relating to oil and hazardous substances liability. Congress also in 1972 passed the Environmental Pesticides Control Act and the Marine Protection Research and Santuaries Act, both containing reference to the problem of hazardous wastes. Proposed legislation is also in the Congress relating to regulation of toxic substances.

Thus it is apparent that the nation as a whole is expressing rather broad concerns in the area of hazardous materials and wastes.

Study Overview

As mentioned previously, Congress did not provide a definition of "hazardous" in the sense of a definition that could be utilized as a working tool either for identifying a hazardous waste, for designing treatment processes or disposal methods, or for development of regulatory programs.

The problem in definition arises firstly from the fact that the term "hazardous" is inherently a relative as opposed to an absolute term. A second difficulty is that we recognize many types of hazards:

1. Flammability - usually an acute rather than a chronic hazard, but under certain circumstances can be latent in a disposal operation.
2. Reactivity - either directly as an explosive or indirectly as in combination with a second material.
3. Toxicity - to humans, to animals, and to plants, either terrestrial or aquatic. Note here also that toxicity can manifest its action via a number of pathway and exposure mechanisms, e.g., inhalation, dermal contact, ingestion.
4. Radioactivity - ionizing radiation in general.
5. Bioconcentration - not a hazard in itself, but can be highly significant as experience with certain heavy metals suggests.
6. Irritation and Allergenic - skin and mucous membrane exposure.
7. Genetic Activity - carcinogenic, mutagenic, and teratogenic.

In addition to the term "hazardous" being a relative one, it has two distinct connotations one of which relates to the intrinsic nature of the waste or material itself, or the amount of damage it can do to man and the environment. The second connotation relates to extrinsic factors such as the degree of exposure including quantity, behavior, delivery mechanisms, and circumstances surrounding exposure. In the intrinsic connotation, the information required for assessing the degree of hazard is specific to the waste; in the extrinsic connotation, the assessment is dependent upon the individual waste management or disposal systems.

That people have struggled with the classification and designation is evidenced by the fact that in 1970 there were more than 30 classification systems addressed to hazardous materials during transportation operations alone and, in general, none of these fully addressed human and environmental protection in any complete sense.

As an initial step, development was undertaken of a model that would enable the decision as to whether a waste was hazardous or not. Figure 1 illustrates the logic by which it is possible to come to some rational judgment as to when a waste should be considered. In effect, the model consists of a series of screens, one or more for each mode of hazard. The mesh size of the screens are set based upon past experience and upon generally accepted available standards for public health and environmental protection.

A note of caution is in order: unfortunately, the majority of the available quantitative information on hazard properties refers to relatively pure compounds and generally not to practical waste materials.

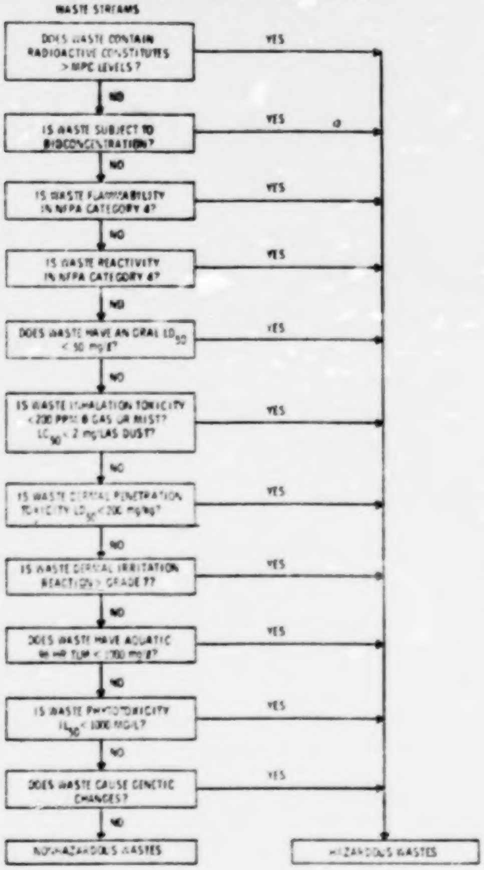
The above rationale does not take into account the extrinsic factors mentioned earlier, e.g., quantities involved, degree of population exposure, etc. It should be apparent that simplistic application of a designation system independent of the extrinsic factors would result in administrative and regulatory chaos. As a consequence, some priority-of-concern must be inserted into the system.

In addition to the basic questions of designation and priority, the management of hazardous wastes involves a number of other technical, economic, and administrative issues that distinguish it from other solid waste problems. The technical issues are:

1. Wastes are Mixtures - and the hazardous ones are no exception. The difference, however, is that the hazardous constituent may constitute only a small fraction of the total quantity.
2. Multiplicity of Sources - generation of public and private sources.
3. Time Dependence - wastes will vary with industrial technology and perhaps most particularly with

FIGURE 1

GRAPHIC REPRESENTATION OF THE HAZARDOUS WASTE DECISION MODEL


WASTE STREAMS
DOES WASTE CONTAIN RADIOACTIVE CONSTITUTES > MPC LEVELS?
IS WASTE SUBJECT TO BIOCONCENTRATION?
IS WASTE FLAMMABILITY IN NFPA CATEGORY 4?
IS WASTE REACTIVITY IN NFPA CATEGORY 4?
DOES WASTE HAVE AN ORAL LD_{50} < 50 mg/kg?
IS WASTE INHALATION TOXICITY < 200 PPM @ GAS OR MIST? LC_{50} < 2 mg/l AS DUST?
IS WASTE DERMAL PENETRATION TOXICITY LD_{50} < 200 mg/kg?
IS WASTE DERMAL IRRITATION REACTION > GRADE 7?
DOES WASTE HAVE AQUATIC 96 HR TLM < 1000 mg/l?
IS WASTE PHYTOTOXICITY IL_{50} < 1000 MG/L?
DOES WASTE CAUSE GENETIC CHANGES?
YES
NO
a
NONHAZARDOUS WASTES
HAZARDOUS WASTES

implementation of air and water effluent standards, leaving but one sink for disposal.

4. Technical Sophistication Level Involved - a markedly higher level is required in the handling, processing, disposal, and monitoring in waste management operations.
5. System Elements - like other solid waste management programs, a number of elements are involved. These include collection, concentration, and storage of wastes at points of origin, processing either by destruction, inerting, detoxification, or isolation at the point of origin; transport to separate processing site; processing; transport of hazardous residues; disposition of hazardous residues; and disposition of nonhazardous bulk residuals.
6. Siting of Processing and Disposal Operations - a number of factors are involved including the proximity to points of origin, isolation from the population, the earth sciences e.g., hydrology, geology as they pertain to long-term perpetual isolation. One conclusion is that hazardous waste processing systems may resemble small chemical plants and may not pose any undue threat to public health and the environment. However, final disposal sites may contain appreciable hazard inventories and hence require special attention in site selection, design, and monitoring.
7. Standards and Measures of Performance - technical criteria will be required for site selection and for performance of waste management elements. Since hazardous waste management is only one of several aspects of environmental and public health protection, the need for compatibility with other standards and criteria is apparent.

There are a number of economic issues also involved in hazardous waste management:

1. Cost - this will be considerably higher in comparison to that involved in other solid waste management areas and more capital intensive. One unique element is that of the cost of perpetual care.
2. Economic Burden - since the origins of hazardous waste are widely scattered between private and public sources, some means must be found to equitably distribute the economic burden of management so that costs flow to the benefactor of the waste production activity.
3. A Fledgling Industry Exists.

Finally, there are a number of administrative issues involved.

1. Many administrative options are open for the management of hazardous wastes. These range from doing nothing, i.e., maintain the status quo, all the way to a grand national system implied by the language of Section 212.

2. The role of regulation - regardless of what implementation option is elected, it is apparent that a regulatory element must be involved if the system is to work at all.
3. Perpetual Case - in certain instances it may be impossible to completely inert a hazard and administrative provision must be made for storage in perpetuity.
4. Finally, there is already some considerable private involvement in processing and disposal of hazardous wastes and private industry is by far the largest producer of these wastes and hence the benefactor of the operations resulting in their generation. Thus, the administrative system must include major private sector involvement.

In working with these issues, Battelle undertook initially to develop a national picture of how much and what types of hazardous wastes should be of concern. This effort extended particularly along the lines of trying to characterize how wastes appear in the real world. Radioactive wastes were also covered in the study but present a distinctly different problem of less general interest.

It was concluded that the aggregate quantity of nonradioactive hazardous wastes being produced today in the United States amounts to approximately 10 million tons annually. These wastes include miscellaneous inorganic compounds, halogens and interhalogens, miscellaneous organic materials, pesticides, and organo-halogen compounds.

Present and potentially applied hazardous waste mangement methods, including processing and disposal, were also evaluated (a total of some 39 physical, chemical, and biological processes were included) leading to selection of nine physical/chemical processes. Biological processes were rejected because of the toxic nature of hazardous wastes and the expected variable chemical character and throughput which would tend to continuously upset such operations. The processes finally selected include:

1. Neutralization (of acids and bases)
2. Oxidation (of cyanides and other reductants)
3. Reduction (of chromium-6 and other oxidants)
4. Precipitation (removal of heavy metals)
5. Flocculation, sedimentation, and filtration (for separation of solids from liquids
6. Carbon sorption (removal of organics)
7. Incineration (of combustible wastes)
8. Ammonia stripping (for ammonia removal)
9. Evaporation (concentration of waste brines).

On a national basis, and using the above processes, a model processing facility design was developed and estimates prepared of capital and operating costs. In practicality, it is expected that plant sizes, specifics of design to accommodate feed stocks peculiar to the service area, and geographic distribution will evolve as a consequence of market forces. A reasonable prediction, however, is that the national needs can be met in the near term with five large-sized and fifteen medium-sized processing plants. On this basis, the overall national costs will be about $800 million in capital investment and about $580 million per year for operating costs.

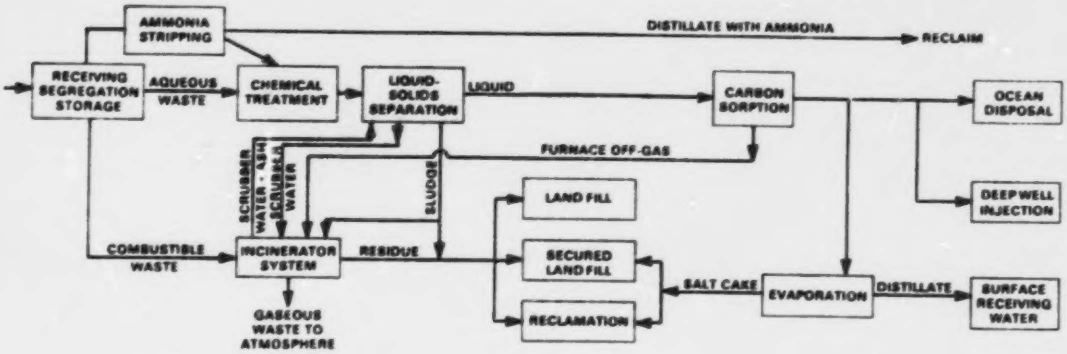
Disposal methods for liquid and solid wastes generated by the processing facility include ocean dumping and deep well injection for liquid brine wastes which do not contain hazardous constituents and landfilling for solid wastes. Landfills consist of two types: 1) secured landfills especially designated for the disposal of sludges containing significant concentrations of hazardous substances (e.g., arsenic), and 2) conventional landfills for burial of solid wastes which do not contain significant concentrations of hazardous substances. Perpetual surveillance must be maintained over the secured landfill as in a radioactive waste burial site.

Figure 2 illustrates the model overall process flow diagram. Typical investment for such a plant would be about $24,000,000 with an operating cost of about 20 cents per gallon of waste received and incineration cost of about $175 per ton.

In addition to the engineering work described, examination was made of the questions of plant siting and financing considerations, and federal and state legislation and regulations, and our findings are included in the final report.(2)

FIGURE 2

CONCEPTUAL MODULAR FLOW DIAGRAM


AMMONIA STRIPPING
DISTILLATE WITH AMMONIA
RECLAIM
RECEIVING SEGREGATION STORAGE
AQUEOUS WASTE
CHEMICAL TREATMENT
LIQUID-SOLIDS SEPARATION
LIQUID
CARBON SORPTION
OCEAN DISPOSAL
FURNACE OFF-GAS
SCRUBBER WATER - ASH
SCRUBBER WATER
SLUDGE
LAND FILL
DEEP WELL INJECTION
COMBUSTIBLE WASTE
INCINERATOR SYSTEM
RESIDUE
SECURED LAND FILL
SALT CAKE
EVAPORATION
DISTILLATE
SURFACE RECEIVING WATER
RECLAMATION
GASEOUS WASTE TO ATMOSPHERE

Status of Technology

In the main, the process technology for the management of hazardous wastes currently exists. However, certain technical aspects require further resolution. These include:

1) The impact of air and water regulations on residuals management is unclear.
2) Improved criteria are required for ultimate disposal and perpectual care.
3) Disposal site evaluation and selection criteria need to be more adequately developed.
4) Better means for accommodation of non-hazardous residuals need to be formulated.

References

(1) Report to Congress on Hazardous Waste Disposal, U.S. Environmental Protection Agency, June 30, 1973.

(2) Program for the Management of Hazardous Wastes. Report Prepared for the U.S. Environmental Protection Agency, July 1973.

INDUSTRIAL CONTROL TECHNOLOGY & THE 1972 WATER POLLUTION CONTROL ACT

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ABSTRACT

A summary of recently enacted regulations is given with a discussion of their effects on the operation and expansion of Philadelphia treatment plants. The discussion is directed to portions of the Act where additional research seems necessary to ensure adequate, but reasonable, environmental management. Areas of possible conflict with other environmental laws are also pointed out. The potential impacts on Philadelphia of eliminating ocean dispersal are also presented. Philadelphia has projected both potential cost effects and environmental effects of such action. One such result could be considerable delays in plant upgrading due to the lack of a viable alternative in the highly populated Philadelphia area.

INTRODUCTION

After reading the information concerning this meeting and its purpose, I concluded that I should speak here today in an effort to contribute the municipal viewpoint.

TEXT

As a municipal spokesman, then, the idea of the conference is good and certainly needed. The conference is asking 'Do we have the technology to meet out needs'? and I am assuming that the needs are not simply the requirements of the law but the requirements for achieving a proper quality in the Nation's waters. Further, if we do not have the technology, where are we short and what do we need to do?

The fact that this meeting is being held at Battelle and jointly sponsored by the Cincinnati group of the EPA leads me to believe that this is a way of ascertaining whether present research efforts are adequate and, if not, what type of research should be done in the future.

I am certainly grateful for this opportunity to participate and relay some thoughts - and I have many - concerning the laws, present technology, and what I feel we need now, as well as in the future.

I must admit that I am surprised by many facets of PL 92-500, the major water law, and PL 92-532, which is the Marine Protection and Sanctuaries Act.

Perhaps many of you have not felt the impact of the Marine Act, but those municipalities that are close to the ocean or have the advantage of dispersing sludge at sea have been influenced by this law. The law seems to contain contradictions which could drastically change the method of sludge disposal used by coastal cities, all to the detriment of the environment.

All of us in the field must have studied these major laws and attempted to explain to ourselves their necessity, or more simply, how they came to be written as they are. I believe that all of us - whether we agree or do not agree, generally speaking, with all the facets of the law - have concluded that the laws are necessary, despite any faults, and a giant step towards halting many abuses of our natural resources and producing a better place for us and our children to live.

It is my feeling, however, that the laws are a result of the impatience of both Congress and the general public for progress in cleaning up the environment. Many of the inadequacies come from a desire for a common denominator in order that the laws can be implemented nationally.

Unfortunately, the common denominator concept ignores many things that we as engineers or scientists have learned. Most important of these is that all streams are not equal and that all streams as well as other bodies of water, be it lakes or the ocean, need not be treated equally.

It is also apparent that the laws are so ambitious in their attempt to be complete that they have actually handicapped their own implementation. I feel this way because the EPA, in attempting to follow the letter of the laws, has found it necessary to prepare very intricate and time-consuming requirements thus making implementation of the laws very difficult.

It is not my intention to dwell too much on the laws, but it certainly would have been dishonest of me not to tell you of the need for clear laws and simpler, uncomplicated regulations. As it stands now, people like myself, whose responsibility it is to follow the law, are not able to do so.

They say that one picture is worth a thousand words. Not too long ago, as shown in Figure 1, if I were required to build a treatment plant, I would simply write for permission from the State, receive a reply and a permit, and construction would begin. Now the procedure is somewhat like that represented in the 'rat maze' shown in Figure 2. I wish to remind you that, as the figure states, this is only part of what is actually required.

I don't blame any one agency for this, it just seems that to correct a mistake in the past, we must now check with every agency that has some relationship with plant construction before we can proceed. The odds of clearing through all of these agencies unscarred and unthwarted are remote. There is always someone against something no matter how noble it may appear to be.

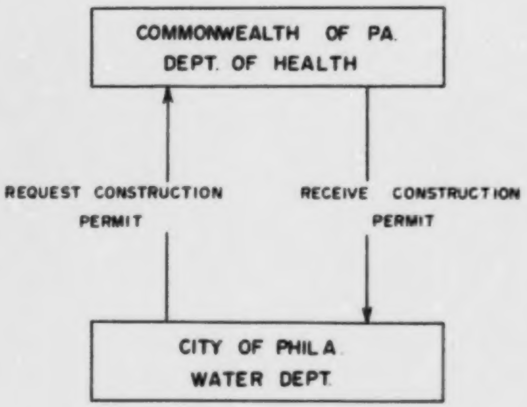
It is ironic to us in trying to build treatment plants that while I have plans and specs ready to advertise for $100 million of work towards cleaning up the Delaware River, I can't do so because there are so many handicaps - from infiltration/inflow analyses to an environmental impact statement - which must be cleared. I know there is some justification for all this, but the net result is a slowdown.

Concerning technology assessment, I will try to summarize what we have done and what we are doing in Philadelphia. I would like to tell you some of our problems, as well as the problems we will have to solve, in attempting to both implement the law and to improve the quality of the environment. I say that because they aren't always the same.

All dischargers into the Delaware River have received an allocation. This was determined, by a mathematical model, to be the amount of carbonaceous BOD the river could take at the discharger's point of entry and still enable the river to meet the quality and use requirements.

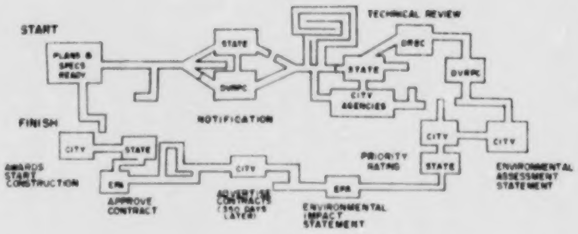
Figure 3 gives the allotment of all three Philadelphia plants. What should be noted here is that, even though the basic

Figure 1.


COMMONWEALTH OF PA.
DEPT. OF HEALTH
REQUEST CONSTRUCTION PERMIT
RECEIVE CONSTRUCTION PERMIT
CITY OF PHIL A.
WATER DEPT.

FORMER BUREAUCRATIC SYSTEM

Figure 2.


START
PLANS & SPECS READY
STATE
DVRPC
NOTIFICATION
TECHNICAL REVIEW
DRBC
STATE
CITY AGENCIES
DVRPC
CITY
CITY
ENVIRONMENTAL ASSESSMENT STATEMENT
PRIORITY RATING
STATE
EPA
ENVIRONMENTAL IMPACT STATEMENT
CITY
ADVERTISE CONTRACTS (350 DAYS LATER)
EPA
APPROVE CONTRACT
STATE
CITY
FINISH
AWARDS START CONSTRUCTION

OBJECT
GET THRU MAZE BEFORE EFFLUENT STANDARDS ARE CHANGED OR YOU'RE PUT IN JAIL OR FINED FOR NOT MOVING FAST ENOUGH

OVERSIMPLIFIED VERSION
OF HOW TO BUILD A
TREATMENT PLANT

Figure 3.

DRBC ALLOCATIONS

PLANT	POUNDAGE OF CARBONACEOUS OXYGEN DEMAND	BOD_5
NORTHEAST	69,300	40,500
SOUTHEAST	33,200	19,400
SOUTHWEST	37,300	21,800

Figure 4.

UNOX PILOT PROGRAM RESULTS - S.W. & S.E.

PHASE	SEWAGE SOURCE	RT_t (Hrs.)	F/M	MLVSS (PPM)	EFFLUENT			% REMOVALS*		
					BOD	SOL. BOD	SS	BOD	SOL. BOD	SS
I	SOUTHWEST	1.6	0.45	3450	11	6	18	89	90	84
II	SOUTHWEST	1.0	0.94	2530	15	10	20	85	82	84
III	SOUTHWEST	0.8	1.56	2500	17	11	19	87	83	80
I	SOUTHEAST	1.2	0.83	2860	9	6	19	91	90	78
II	SOUTHEAST	0.7	1.87	2110	7	5	7	93	93	91

BOD_5 (mg/l) REQUIRED TO MEET ALLOCATION IN 1980 S.E.=17 S.W.=12
* REMOVALS FOR SECONDARY PROCESS ONLY

law at this point in time requires secondary treatment, regardless of what percent you remove, you must keep the quality of your discharge below the point where it will adversely affect the river. As time goes on, I believe we will see more of this type of river quality control. After all the river does not recognize 5-day BOD it recognizes total impact BOD. It follows that you cannot apply the success formula from some other city, be it New York or Chicago, to Philadelphia due to differences in the quality and capacity of the receiving streams.

We conducted a series of pilot plant studies which are still in progress today. Figure 4 will give you some results of this pilot plant work and based on these results, we have chosen for two plants - the Northeast and Southwest Plants - the Unox or oxygen process over the conventional or chemical-physical treatment.

We have operated pilot plants at all treatment plants and have found that the wastes from various sections of the City respond differently. This shouldn't surprise anyone, but it should certainly alert us that the choice of treatment is risky if you do so from a text book or simply from the literature.

Philadelphia industry has a big impact on the waste of the Northeast and Southwest Plants, but in spite of that the Unox process was able to accomplish very good removals. The oxygen process has many advantages as shown in Figure 5.

However, the oxygen process as well as the conventional methods do require a lot of power; that is, 45 KW per 100 Lbs. BOD removed. The energy crisis has accented the need for a process that requires a minimum of maintenance and supervision Accordingly, for the last several years, we have piloted different size rotating units. Figure 6 is a schematic diagram of the process.

We have tested these at all the plants and at the present time, we have a large scale pilot unit in operation at the Southeast Plant. The rotating contactor required 34 KW per 100 Lbs. BOD removed. Although I have not come to a firm conclusion, my feelings are very strong that I will choose a rotating contactor for the Southeast Plant. The plant will have a capacity of 140 MGD. As the results in Figure 7 show, we were able to surpass removal levels experienced by the Unox process.

INSTRUMENTATION & AUTOMATION

Instrumentation and automation of the treatment process will produce a uniform effluent. Figure 8 shows what can be accomplished once the process has been automated. Instrumentation and automation is vital for small plants as well as large. The main deterrent are the sensors necessary to pace the treatment process.

Philadelphia, however, is planning to automate wherever possible. We have found out that as you go through the program writing, which is part of computer control, the logic required takes some of the art out of operating a treatment process and makes it more of a science, Until we are able to apply more instrumentation and automation to the treatment plants throughout the country, treatment plant efficiency will vary from plant-to-plant, operator-to-operator, etc. I have visited many plants in the last few years and have found very few operating at what I would call optimum efficiency.

For the most part, plant operators are busy keeping the mechanics of the plant in operation and spend a minimum amount of time in actually controlling the process. Many of the operators do not have the proper education to control a biological or chemical process and are using rules of thumb to operate.

Perhaps this facet of operation will be corrected, but I think it won't be for quite some time. What we need is instrumentation and automation to automatically assure a good effluent.

Figure 5.

WHY OXYGEN ACTIVATED SLUDGE CHOSEN

1. CONSISTENT TREATMENT OF STRONGER WASTES (HIGH SOLUBLE BOD)
2. MORE ECONOMICAL THAN CONVENTIONAL
3. LESS LAND AREA REQUIRED
4. GOOD SLUDGE SETTLING CHARACTERISTICS
5. LESS SLUDGE GENERATED

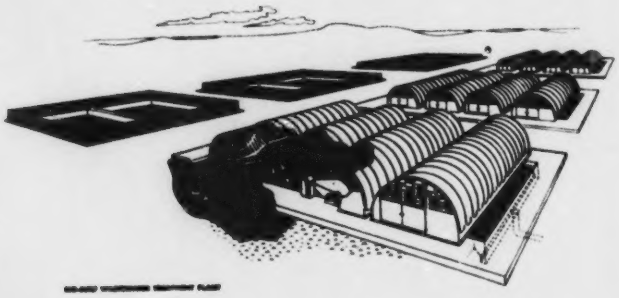


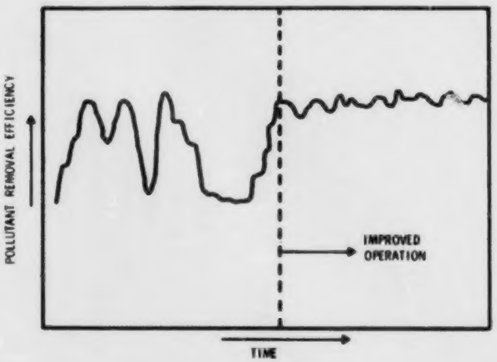
Figure 6.

Figure 7.

NE BIO-SURF

gpd/ft.^{2}	REMOVALS * BOD	REMOVALS * SS
1.4	95.7%	92.8%
2.6	95.2%	96.1%
3.0	94.0%	95.0%

* NOT INCLUDING PRIMARIES



VARIATION IN EFFICIENCY CAN BE REDUCED BY IMPROVED OPERATION

Figure 8.

We have worked out most of the details to instrumentate and automate the new Philadelphia plants. Figure 9 shows what we are now using at the Southwest Plant to automate the operation of a primary tank. Figure 10 shows the basic method that we will use to automate the Unox process.

AUTOMATIC SLUDGE PUMPING
SOUTHWEST TREATMENT FACILITY

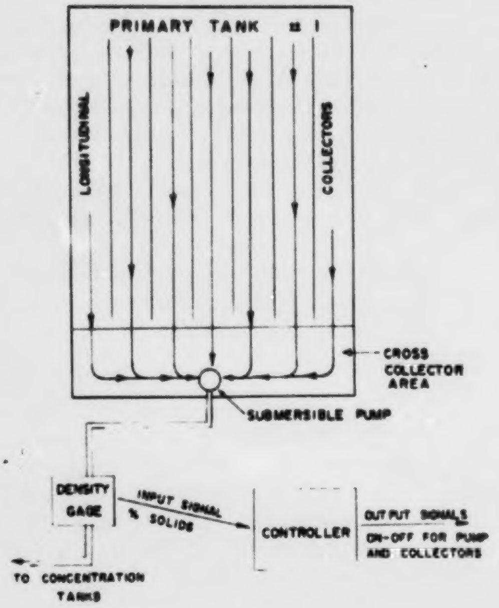

PRIMARY TANK # 1
LONGITUDINAL
COLLECTORS
CROSS COLLECTOR AREA
SUBMERSIBLE PUMP
DENSITY GAGE
INPUT SIGNAL
% SOLIDS
CONTROLLER
OUTPUT SIGNALS
ON-OFF FOR PUMP AND COLLECTORS
TO CONCENTRATION TANKS

Figure 9.

As I mentioned, the big drawback are the sensors to determine suspended solids as well as BOD. At one time, I thought nothing would replace BOD. However, I have changed my mind.

As we look toward advanced treatment, tertiary treatment and, finally, water re-use, the BOD does not completely fill our needs. It is apparent that there is much more in wastewater than is registered by the BOD test.

Philadelphia's giant chemical firms such as Rohm & Haas and Allied Chemical Company pour thousands of pounds of organics into the City sewer system each day.

OXYGEN CONTROL SYSTEM

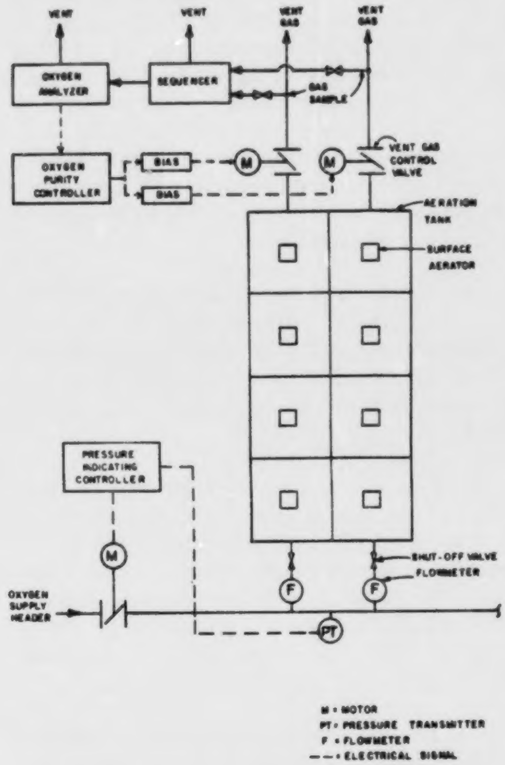

VENT
VENT
VENT GAS
VENT GAS
OXYGEN ANALYZER
SEQUENCER
GAS SAMPLE
OXYGEN PURITY CONTROLLER
BIAS
BIAS
M
M
VENT GAS CONTROL VALVE
AERATION TANK
SURFACE AERATOR
PRESSURE INDICATING CONTROLLER
M
SHUT-OFF VALVE
FLOWMETER
F
F
OXYGEN SUPPLY HEADER
PT
M = MOTOR
PT = PRESSURE TRANSMITTER
F = FLOWMETER
--- = ELECTRICAL SIGNAL

Figure 10.

These organics are the result of synthesis of organic compounds they sell. These companies readily admit they are not able to identify all the byproducts. If these organics do not register a BOD or if they are not oxidized in any reasonable time frame, they could easily be found in our water supply.

It is my feeling that tests like COD are becoming more important and will be used in the control of the treatment process, particularly where advanced treatment, tertiary treatment, or re-use is intended.

We have attempted to determine the compounds that enter our treatment plants.

We have not been able to complete this work, but we have found some interesting data. A spectrographic analysis of the influent of the Northeast Plant showed the presence of many compounds that we have not been able to identify. A spectrographic analysis of the effluent gave similar results . In the effluent analysis, many of the influent compounds are no longer present, but other unknown compounds have appeared.

Truly, there is a need for a good chemical test to more completely evaluate treatment plant performance since there is more to be evaluated than the impact of suspended solids or oxygen depletion in the receiving stream.

As for tertiary or advanced treatment, there have been volumes devoted to this topic but in my opinion, we have not found an economic method. Methods available today are extremely expensive and could not be used by large or even medium-size cities without a tremendous increase in cost to the customers.

It is my guess that a cost/benefit analysis would not justify the construction of advanced or tertiary treatment facilities in Philadelphia. The cost of the present expansion program in Philadelphia will produce a 50% increase in rates to the people of Philadelphia. Tertiary treatment would more than double this increase.

PRETREATMENT OF INDUSTRIAL WASTE

Since there is so much industry in Philadelphia, it does have a considerable impact on our treatment process and since we consider industry part of the City and a part of our prosperity, we are concerned as to what the impact of the water laws would be on them.

Proven and economically justifiable techniques for pretreatment of industrial wastes are needed in order to implement the intent of the '72 law. This statement is particularly true for urban based industries where space is either not available or only available at an extremely high cost.

The key word here is "proven". No industry can really afford to purchase equipment which upon installation does not solve their problems. The creation of deadlines in the law, which I do not feel are realistic, has fostered a need for a type of panic investment.

Some large firms can support equipment manufacturer's research and development, but the facts are, for example, that a great deal of air pollution control equipment sold in the last 5 years has had to be discarded as scrap. Even though some large firms have been able to afford this type of research, most medium and small size firms cannot afford to do this.

Even such mundane problems as removing grease and oil, particularly where an industry does not have the required area, is very difficult.

We wonder if there is any method of obtaining the suggested limit of 100 mg/l of hexane extractables through pretreatment. Our knowledge on the subject indicates that perhaps this can be done. As far as we are concerned, however, it is in the developmental stage.

Contrary to general belief, simple neutralization is not really simple. Reliable systems to meet the intent of the law still need to be developed. Having worked with industry, I know their problems. I would have hoped the law would have allowed the affected industries to obtain necessary grants to pursue research to solve the many problems that plague them. I feel sure something could be worked out to the extent that any patents be owned by the US Government. I further feel that unless this is done, progress in solving our industrial waste problems will be slow.

Also, research is needed into the problems created by the removal of pollutants through pretreatment. For example, some of the heavy metals in plating waste can be removed by pH adjustment and hydroxide precipitation, but after this is done what is done with

The second is the development of management techniques and related technology that can uniformly and accurately assess the impacts of all disposal alternatives including ocean disposal.

Philadelphia's digested sludge exceeds the criteria of the act for only two elements; mercury and cadmium in the 'solid phase'. The analysis procedures used to determine these concentrations are in draft form and many EPA Regions have analytical methods of their own . Here is an area where further development is needed.

Also, it is unclear from the wording of the Act as to what is intended by the distinction between solid and liquid phases for mercury and cadmium when all other substances are limited by the bioassay test. Philadelphia's discharge rates and bioassay results are well within the criteria but we may be forced to abandon the ocean by concentrations of mercury and cadmium that have already met the toxicity limitations. The criteria appear to be protecting organisms found in the barge, not marine organisms.

To effectively implement PL 92-532, serious consideration must certainly be given to the validity of restricting ocean disposal by concentration values in the sludge which are by no means an indication of concentrations expected in the ocean after discharge and instantaneous dilution.

Once analytical procedures are established and the scientific validity of the limiting concentrations is proven, technology for removing substances like heavy metals must be developed.

This will afford an option, presently unavailable to ocean dumpers, of either removing the objectionable material or removing themselves from the ocean.

However, sludge will not be a major source of metals and, unless a major technical breakthrough occurs, metal recovery from sludge will be expensive and will not "produce" an offsetting quantity of usable metal.
the materials you have removed? In Pennsylvania, none of our landfills will accept this type of waste. It is clear that research and development of approved disposal techniques are needed, but this is a secondary goal. The primary goal would be to recycle as much of the waste as possible. Past developments of recycling techniques have been hindered by an abundance of raw material. Even though I do not have a crystall ball, it is easy to predict that within a few years, we will see numerous shortages in the way of iron, aluminum, copper and many other materials.

Research is also needed for substitutes. For example, the vast majority of cadmium plating done in Philadelphia is for Federal Specification QQP-416. We wonder if this specification is necessary for all parts or can a substitute such as zinc be used. In fact, can substitute coatings be developed? Also, some firms have found substitutes for mercury in their latex paints. Can all firms switch? If not, why not develop suitable substitutes. The same can be said for other metal pigments in paints and inks.

As we examine industry and look around us, we see many things in their manufacturing which will produce either a treatment problem or have an impact on the environment in which we live. It appears that a general re-appraisal of how we live is necessary.

To complete this section on industrial pretreatment, I will state, without any doubts, that industry will not meet the '77 requirement of the law because they do not have the means or technology necessary.

SLUDGE DISPOSAL

There are two basic requirements for implementing the Marine Protection, Research and Sanctuaries Act. One is the development of technology that will remove substances from the waste that are above the limits of the criteria.

In writing the Marine Protection Act, the authors apparently were able to project the impacts on the ocean environment of the many substances listed in the criteria. In the meantime, however, no one - including the EPA - has been able to document by field surveys, even where Philadelphia's sludge goes after discharge, much less what the impacts have been. How can this be? It would seem that a law with such obvious economic impacts would be based on what can be shown to be harmful instead of speculation.

One problem we have encountered along these lines is the relocation of our dump site. Philadelphia, in a study performed by the Franklin Institute Research Laboratories, was unable to find any effects of our dumping at a site 12 miles off the coast. In spite of this, we were moved to a 52 mile site, but we were moved before an adequate baseline of the site could be made. Now it will be very difficult to determine anything about our dumping because there is too little data on which to base a comparison. The situation is further complicated by a nearby acid waste dump site which appears to be interacting with the sludge site.

This situation points out the need for study of the proper management of dump sites. If two or more different wastes are being discharged, the interaction of these wastes may produce effects at the site totally different from the effects of the materials considered individually. This case makes comparison of individual wastes to the criteria meaningless. It may be that grouping of compatible waste discharges is needed to avoid hazardous interactions, or on the other hand, to promote any beneficial interactions. In either case, much work is needed.

If ocean disposal of digested sludge is potentially harmful to the ocean, then the same potential exists for other methods such as land disposal or incineration. PL 92-532 requires that dumpers of waste which exceed the criteria investigate alternative means of disposal.

Investigation of alternatives is not the problem, but how to evaluate the relative impacts on the environment has not been clearly established. It is implicit in the passage of the Act that these benefit/damage relationships are known for the ocean, but this is meaningless without the same consideration for other means of disposal. Further, once the acceptable means of distributing pollutants are established for other segments of the environment, a comprehensive study of the relative value of each segment must be made. Only after this is accomplished can municipalities and industry make design decisions on the best means of ultimate disposal.

To illustrate this need, the reports generated as a result of our permit requirements for research into alternatives warrant discussion.

There are three choices for ultimate disposal of sludge solids; the atmosphere, the land, the water. In the report entitle "Report on Management of By-Product Solids from Water Pollution Control Plants" by our consulting engineers, Greeley and Hansen, the alternatives available tp Philadelphia were evaluated on the basis of economic, practical, and environmental concerns.

Economically, all alternatives to ocean dispersal were shown to be much more costly to the City. The present cost to the City for ocean dispersal (including the recent 175% increase) is approximately $17.00 per dry ton of raw sludge. The average cost of the 9 land dispersal alternatives considered was approximately $40.00 per dry ton, an increase of 135%. The incineration (atmosphere) alternate is expected to cost on the order of $62.00 per dry ton, a 264% increase. Ocean dispersal is by far the most economically, attractive disposal method.

Large areas of available land do not exist in the highly populated northeastern United States. This means that long distance transportation methods are needed which would increase operating difficulties, adverse public reaction, energy consumption, and costs.

Also, land spreading may not be done in winter months due to runoff problems and therefore requires large storage facilities. Composting is also expected to have some problems due to cold weather reducing pile temperatures and research is underway at this time to determine the extent of weather effects. Incineration processes need stack gas scrubbing to meet air pollution standards and will require extensive maintenance. Of all the alternatives, ocean dispersal was shown to have the least operating problems.

The environmental evaluation showed similar potential hazards are associated with all dispersal methods. The potential for heavy metal introduction to the food chain exists for both ocean and land dispersal. Clams and other filter feeders could ingest the metals and thus be available for harvesting and ultimately human consumption. In a similar manner, crops grown on sludge enriched soil could be ingested by livestock and also be available for human consumption.

Microorganisms associated with sludge pose threats whether introduced directly to ocean waters or indirectly through percolation to ground waters. Air pollution hazards are unique to incineration processes since operation of air scrubber equipment has been insufficient to date. Incineration is also a high energy consumer, as is land spreading when compared to barging to sea.

The report states that both sea dispersal and land dispersal have the advantage of supplying nutrients to nutrient-deficient areas. The report also points out, however, that sea dispersal has the advantage of diluting potentially hazardous materials that land dispersal does not, while land dispersal does provide somewhat better control.

Overall, ocean dispersal did not appear more hazardous to the environment than the other alternates considered and if aesthetics and public relations are considered, it appears as the best choice again.

In spite of the considerations listed above, Philadelphia may be required to choose one of the alternatives to ocean disposal simply because we exceed criteria that has been put into effect before sufficient knowledge of the impacts on the total environment was developed.

One final note on sludge disposal. Effluent criteria for Philadelphia necessitates upgrading all three treatment plants to full secondary systems. Secondary treatment will, by its nature, increase the volume of sludge and the amount of potentially hazardous materials it contains. Ocean criteria, however, dictate a reduction in the amounts of potentially hazardous material in the sludge before disposal, as do incineration and land-based alternatives. This somewhat paradoxical situation also implies that a system for assessing impacts of laws and regulations on all parts of the environment is needed.

SUMMARY

I hope that I have given you an idea of some of the things that we are doing in Philadelphia as well as some things that must be done if we are to meet environmental requirements. It is my feeling that because of the growing shortage of raw materials, we will have to develop better methods for recycling with the net result of less wastage.

As far as secondary treatment is concerned, I do think we have the ability to accomplish this if we use a common yardstick of BOD and Suspended Solids. However, if we intend going beyond secondary, we need methods which are practical and economical and we must use other tests such as the chemical oxygen demand (COD) particularly if we intend recycling. There are signs that the generally accepted concept of B-Coli as an indicator is now being considered pathogenic. I would suspect that this will change the bacteriological requirements of both drinking water and the effluents from sewage treatment plants.

The rotating contactor has tremendous possibilities since it requires little power as well as supervision. Much work is to be done concerning storm overflows. The huge quantities involved present real problems as far as treatment is concerned. This is a particularly tough problem in large cities like Philadelphia where each time it rains, sewage plus stormwater enters the river.

Finally, in my opinion, the biggest problem continues to be sludge disposal. It is one thing to remove pollution - it is another to safely and economically dispose of the pollution you have removed.

SESSION IV: ACTIVITIES INDIRECTLY AFFECTING WATER POLLUTION CONTROL

Moderator:
C. J. Dial
U.S. Environmental Protection Agency

LAND USE AND WATER QUALITY

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ABSTRACT

The interaction between land use and water pollution promises (along with the air pollution/land use interaction) to become one of our most important environmental issues. There are two aspects to the problem. The first is the impact of alternative patterns of land use on water quality. The second is the impact of water quality regulations on land use. The importance of land use patterns on water quality in urbanized areas is indicated by the fact that urban runoff promises to be the most important source of water pollution in urban areas after the 1977 water pollution control standards are met. The other side of the problem will be more evident over the next few years. The location of treatment plants and intercepter and collector sewers will be a most important influence on how land is used. The water quality maintenance regulations will also have a substantial impact on land use decisions.

INTRODUCTION

It has always discouraged me that we often approach our environmental problems with such a narrow focus. We see a water pollution problem and we set out to correct it, with little concern about the air pollution, solid wastes, or land use effects that may result. But now we are finding that we have gone about as far as we can, and perhaps further than we should have, with this single focus approach. Things are more frequently running into one another. And, more pertinent to the topic of this paper, they are all running into the problem of land use.

There is increasing -- perhaps not yet widespread, but increasing-- realization that many pollution abatement programs are impacting land use. Their impacts may be substantial. And they may be detrimental-- the land use impacts resulting from pollution abatement efforts may end up generating more pollution.

The other side of the issue is just as important, and in the long run perhaps even more important. Although tens of billions of dollars are spent on pollution abatement, efficiently achieving the degree of environmental quality we want may still require influencing patterns of land use and development. Land use questions -- what should land be used for, how should it be developed, how should different parcels of land be hooked together -- are where it all comes together. If we can efficiently and effectively deal with land use, we will have accomplished a great deal in efficiently and effectively dealing with many of our environmental problems.

In this paper I will briefly touch on some of the interactions between land use and water pollution. I do not claim to be an expert in this field -- in fact there may now be no such thing -- but I can discuss some of the preliminary work we are doing at the Council on Environmental Quality which is relevant to the issue.

My discussion is divided into two parts. The first deals with some ways in which different patterns of land use have different effects on water quality. And the second will look at the opposite side of the issue -- how efforts to improve water quality affect land use.

Land Use and Waste Water

The first thing we can say about the effect of land use on water pollution concerns the generation of sewage -- domestic and industrial. My comments on this are rather obvious, and I include the subject for the sake of completeness, not because I have anything particularly profound to say. Clearly different land activities generate different amounts of pollution. It makes a fair amount of difference whether there is a paper mill or 20 houses or a golf course located out there on the back forty. One can, therefore, control the amount of waste water generated by controlling what type of activities take place on the land. Hopefully such controls would be oriented toward the amount of pollutants actually discharged to the environment rather than the gross amount generated before abatement takes place. After all, it is possible -- perhaps not likely but still possible -- that the 20 houses with their leaky septic tanks or the golf course with its heavy nutrient and pesticide laden runoff may be worse than the paper plant.

There is a potentially more interesting point in regard to such planning, however. There may be potential synergisms between polluters such that the total amount of pollution generated by an integrated group is less than the sum of the pollution generated by all of them independently. For instance, there are possible uses for the waste heat in the cooling water from power plants. There are also isolated examples such as the Sparrows Point Steel Mill which makes use of treated effluent from Baltimore City. There is potential use for many effluents in irrigation where the nutrients in the effluent water can grow something we want rather than green lakes. If such potential synergisms are more common than these few examples suggest, the grouping of such activities -- which is a land use issue -- may result in reduced pollution at a lower cost. A real benefit.

Non-Point Sources

Let me go on to what I think is a more important interaction between land use and water pollution. This is the issue on non-point source water pollution, and particularly the problem of urban runoff. This problem has received relatively little attention in the water pollution control legislation or in the EPA guidelines and regulations; but is potentially very important to our efforts to clean up our waterways.

Let me review some results from a recent study undertaken for the Council on Environmental Quality.* Urban runoff is a major source of pollution in urban streams. In fact -- comparing storm water runoff with wastes processed by municipal systems -- after we achieve secondary treatment (85% B.O.D. removal) of our municipal wastes, urban runoff becomes the major source of pollution in most cities. The CEQ study looked at 8 U.S. cities, and estimated that, once secondary treatment was in effect, storm water runoff would be responsible for 40 to 80 percent of the municipally generated BOD in the river. Not only is it a major source of BOD, once the municipal and industrial sewage is adequately treated, it is the major source of settleable solids, pathogens and bacteria. It is also likely to be a major contributor of such toxic pollutants as lead and mercury. A moderate sized city contributes significantly more of these pollutants in urban runoff than will a typical industrial discharge.

So storm water runoff is a serious problem. It is also a problem that is strongly affected by land use. There are several different levels on which the relationship between runoff and land use can be considered. At the regional level, there is a question of whether there is sufficient land available in an appropriate location to serve as detention basins for at least the first flush of runoff. It is this first flush -- the first 1/3 to 1 inch of rainfall -- that contains over 85 percent of the pollution. If we could capture this first flush, hold it for a while, let it out slowly, perhaps treating it before we do, we would have much of the urban pollution problem taken care of. It would not be too expensive and would significantly improve our streams. This is an issue for land use planning at the regional level.

At another level -- more appropriate to the community or neighborhood -- one is concerned with the question of whether different land development patterns make any difference on the amount of storm water runoff. The CEQ (in association with HUD and EPA) has just completed another study called The Costs of Sprawl that attempts to look at this issue along with other environmental and economic effects of alternative development patterns.** The findings of this study are fairly consistent across all the environmental and economic costs that were measured. Does density or good planning make a difference? The answer most definitely is yes. The amount of urban runoff is essentially determined by the amount of paved area there is. The more paved area -- in homes, roads, parking areas -- the more runoff and the more storm water pollution. Not only is there more runoff from developed areas, but there is likely to be more sediment as well. Some standard comparisons of sediment production are given in Table 1.

If you ask the question in terms of how different development patterns affect the amount of pollution generated by a thousand families, you find that clustering homes may reduce urban runoff by 25 percent, but that increasing density saves more. A clustered high density development (apartment buildings) may generate only one fifth as much storm water runoff as a conventional single family neighborhood with the same number of dwelling units.

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*Anne M. Vitale and Pierre M. Sprey, Total Urban Pollution Loads: The Impact of Storm Water, study done by Enviro Control, Inc. for the Council on Environmental Quality, 1974

**Real Estate Research Corporation, The Costs of Sprawl, (Washington, D.C., U.S. Government Printing Office, 1974)

However, with the denser developments, the amount of storm water runoff per acre is somewhat slightly higher. This increased runoff per acre also means that the pollution may be more concentrated, which of course will create worse situations in the stream. Thus increased densities will result in a lower total amount but probably a higher concentration of pollution unless it is controlled.

TABLE 1. LAND USE AND SEDIMENT

Land Use	Sediment Production
Wooded	100 t/sq.m/y*
Agricultural	300 t/sq.m/y
Vacant & Open Space	200 t/sq.m/y
Developed, Urbanized	700 t/sq.m/y
Under Construction	2300 t/sq.m/y

*tons/sq.mile/year
Source: Interstate Commerce Commission on the Potomac River Basin, Land Runoff: A Factor in Potomac Basin Pollution, (Harrisburg, Virginia, July, 1967)

This then brings us to the next level of concern. This is the fact that at a level of detail appropriate to a neighborhood or less, there are a number of design modifications that can be made to reduce the amount of storm water runoff and therefore the amount of storm water pollution. If you take a given amount of land and develop it at a high density, you will have enough land left over to permit the construction of temporary holding basins which will catch the runoff and allow it to seep into the ground, thus eliminating the discharge of these pollutants into the streams. Such a holding basin will be dry most of the time and can serve as a park, as part of a golf course, or even in one case I have read about as tennis courts. This type of design modification will not only reduce the amount of pollution, but will also reduce the flooding problems that often appear in rapidly developing areas, and by recharging groundwater supplies will help advert water shortages. This is a clear instance in which imaginative use of the land can avoid several potentially serious water resource problems.

At a finer level of detail, similar types of facilities can be and are being built to catch the runoff from parking lots, roof tops, and so forth. Present design standards seem to serve primarily to ensure that as much of the runoff pollution as possible gets to the stream as quickly as possible. For instance, in some places it may be better to leave the curbs off the streets and allow the storm water to run off the edge of the road to seep into the ground. There are a number of similar design modifications that can be carried out which will make a substantial impact upon the very serious problem of storm water pollution.

Thus we have two ways in which land use affects water pollution; the first concerning sewage generation and the second concerning storm water runoff (which is the more important of the two). Even with reduced population growth rates, a very large amount of urbanization is going to occur in this country before the end of this century -- about as much as has occurred in the past 2 decades. Where and how this urbanization is going to take place will have a very substantial effect upon the quality of our urban waters.

For all the money we spend to clean up our municipal and industrial wastes we may still remain frustrated in our efforts to obtain really clean water if we don't deal with the problem of storm water runoff. And it appears as if the easiest and least expensive way to deal with this problem is through better use of our land.

The Other Side of the Picture

As mentioned in the introduction, there is another side to the water pollution/land use issue I would like to address briefly. We have indicated our concern about the effects of land use on water pollution. But water pollution, water pollution control, and water pollution control regulations also affect land use.

To deal first with the question of the impact of water pollution and water quality improvement upon land use, I can only observe that there is a significant tendency as our rivers and lakes become cleaned up, for water front land to become much more valuable and built up. This has been documented in some research studies, and is apparent to anyone observing building trends in most cities. Large office buildings or luxury apartment houses are beginning to line our urban water fronts. In some ways this is a disturbing trend, for these developments may effectively be blocking the public from taking advantage -- receiving the benefits of -- the improved water quality they have paid for. There are, I think, potentially serious problems of income distribution involved here, which is not a question for this conference. But we ought to recognize that water quality improvement can and does affect significant changes in the price of and use of riparian land. This factor would argue strongly for coordinating land use planning with water quality improvement. If we want to make the improved water quality available to the general public, the acquisition of water front park lands and the like can be done more easily and inexpensively if it proceeds rather than follows the clean up effort.

The way in which we attempt to control water pollution has probably a more important, and certainly a more widespread impact on land use. The construction grants program is most significant in this respect, particularly the monies allocated to the construction of sewers. The availability of sewer facilities has long been important, and is becoming more important in determining whether or not, and how land will be developed -- particularly at the urban fringe. Where there is vacant sewered land, houses will be built. If there is relatively little such land, denser development will take place -- there will be relatively more apartments and town house developments. When there is a surplus of such land, relatively low density development is more likely. However, if there is no vacant sewered land, the more wealthy will construct single family homes on large lots with septic tanks (if the soil is suitable), and large developers will probably "leapfrog" out beyond the urban fringe and serve their developments with small package treatment plants.

Thus, the rate at which sewers are extended strongly impacts land use. If extended rapidly they will support (and to some extent stimulate) low density urban sprawl. If extended too slowly, they may create similar problems. There is probably and optimal rate of extension which will lead to preferred development patterns in preferred locations, although we do not yet have the ability to determine this optimal rate. Nevertheless, it is clear that sewer construction has a most important impact on land use, an impact which ought to be carefully assessed when planning new sewer facilities.

Among other actions being taken to control water pollution which may impact land use are the permit programs, the new source performance standards, the industrial effluent guidelines and the section 208 plans. It would take too long to analyze each of these in detail, so let me summarize some of the possible impacts.

The ability to issue discharge permits gives the water pollution control agency direct control over the location decisions of individual polluters. The agency can refuse to issue the required permit unless it approves of where the factory is constructed.

The industrial effluent standards, on the other hand, may eliminate many of the incentives formally provided by municipal sewers to the location of firms. Combined with the requirements regarding pretreatment of waste water before it is discharged into municipal sewers, and reimbursement of the municipality for the total cost of treating industrial waste, these regulations will tend to reduce industry use of municipal systems. This reduced dependency will result in firms being freer in deciding where to locate and could result in their moving to unsewered areas where the land is less expensive. In this manner, they could accelerate urban sprawl. The regulation's effect will be greater if the water pollution regulations induce old facilities to cease operation before they otherwise would have.

The new source performance standards will provide some counteracting inducements -- at least up through 1982. If the new source standards are much stricter than the standards for old plants, they will provide an incentive for firms to keep the older plants in operation longer than they otherwise would have. This would tend to contain urban sprawl.

Finally -- at least for this discussion -- there are the section 208 plans. These are general area plans which will be directly concerned with the effect of development patterns on water quality. If these plans are solely concerned with water quality, a natural tendency would be to call for a dispersal of waste water discharges so that the streams are not subjected to heavy concentrations of pollutants. In terms of dissolved oxygen, such concentrations are more detrimental than spreading the same amount of pollution over a wider area. Thus the 208 plans may also tend to promote urban sprawl.

Conclusion

That is a brief look at the land use implications of some of the water pollution control regulations. Clearly they provide a complex set of incentives, many of which counteract one another. The complexity of the situation is increased several times over when all the air pollution control regulations are also taken into account. What is good for water quality may not be good for air quality and visa versa. It is impossible to tell at this point where it will all come out. It is, however, a most important issue. Unless the land use effects of the various regulations are carefully considered in their development and implementation, they may generate development patterns, which according to the analysis in the first part of the paper, will increase the amount of pollution generated.

RESOURCES AND WATER QUALITY

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ABSTRACT

This paper discusses the use, consumption, and pollution of water by the resource-acquisition and manufacturing industries in the United States. Once it is established that the flow of materials through the materials cycle (acquisition, processing, use, recovery, and disposition) affects water quality, a review of material and natural resource supply and demand trends, both domestic and foreign, is given.

INTRODUCTION

Since the environment is both the source of materials and the sink for the waste or byproducts of production and use, materials and the environment interact at each step in the flow system. Water quality is especially affected in its use by resource acquisition and manufacturing industries (materials industries). The acquisition, processing, use, and disposition of water, plus the pollutants discharged into it, all affect the quality of available water. Conversely, the quality of water affects its use. Many uses of water are prevented by its natural salinity in arid regions. Moreover, increases in salinity may result from irrigation. Pollution by municipal and industrial wastes, and in some cases by agricultural and urban runoff, often makes streams unfit for uses such as recreation and the propagation of fish, and adds to the costs of conditioning water for other uses. Such pollutants as sediment, temperature, deviations, or biological nutrients may also limit water uses.

USE AND CONSUMPTION OF WATER BY SELECT NONRENEWABLE RESOURCE INDUSTRIES

Mining Industry

The mining industry requires substantial quantities of water. Water use is concentrated in the production of a few commodities. More than 65% of the water withdrawn is used in the following five major operations: quarrying sand and gravel, drilling and secondary recovery of petroleum and natural gas, removing phosphate rock and iron ore, and natural gas processing.

In 1965 the mineral industry withdrew an estimated 3.2 b.g.d (Table 1). Of this water, 64% was used for processing and 27% for cooling. About 6% was used in mining operations and the remainder for boiler feed and sanitary service.

Water consumption in 1965 was about 0.7 b.g.d. -- almost 25% of the total U. S. consumption. The

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Table 1. Past and projected water requirements for the minerals industry in the United States

	1965	1980	2000
		(in b.g.d.)*	
Gross	11.10	20.0	33.0
Recirculation ration	3.43	4.9	7.0
Withdrawal	3.24	4.1	4.7
Discharge	2.48	2.9	3.3
Consumption	0.76	1.2	1.4

*b.g.d.: Billions of gallons per day

Source: National Commission on Materials Policy Report, June 1973

relatively high consumption rate is due in part to the temperature and aridity of the areas in which much of the mineral industry is located. The industrial practice of multiple recirculation of process and cooling water through ponds and cooling towers, however, causes large losses through evaporation even in humid climates. About 20% of the waste water discharged presently receives some treatment -- pH control, precipitation, or settling. The overall effectiveness of these processes, however, is not known.

Except in certain arid areas in the West, water supplies for mineral industry withdrawals are not a major problem. However, industry's wastes, including drainage and seepage from mines and pits, contribute to water pollution. Acid mine waste from coal fields in humid areas is a serious pollutant.

Coal Gasification

The most recent studies and estimates of water needed for a 250 million cubic feet per day synthetic natural gas plant indicate a requirement of approximately 100,000 g.p.m. circulated in the plant with actual consumption that could be as high as 20,000 g.p.m.

The Department of the Interior's projections of energy requirements indicate that 5,500 billion cubic feet of synthetic gas may be needed by the year 2000, of which 90% would come from coal. An industry of this size would require large volumes of water for circulation, with consumption amounting to about 20% of the total.

Oil Shale

The water needs for consumptive use in a million-barrel-a-day shale-oil industry are estimated to approximately 100 to 170 m.g.d. These estimates represent requirements for production of a high-quality shale oil syncrude, including a partial refining of crude shale oil that involves hydrogeneration.

The Department of Interior tentatively projects the annual production of 1,500 million barrels of shale oil by the year 2000. This would mean consumption of about 400 to 700 m.g.d. at the rates estimated above. The oil shales with a development potential are located largely in the upper Colorado region, whose sparse water resources are already heavily committed. However, large amounts of ground water are available to support initial developments. Over time, increasing amounts of surface water will be required. Ultimately, surface water supplies may limit the size of the shale oil industry to perhaps 3 to 5 million barrels of production per day.

Manufacturing

Water use for manufacturing and processing of materials is concentrated in relatively few large establishments. About five major industry groups (food and kindred products, pulp and paper, chemicals,

Table 2: Typical water consumption for a 50,000 bbl/day oil shale plant.

Assumptions: (1) Process sequence includes underground mining, surface retorting, processed shale disposal by wetting and compaction, upgrading of shale crude by partial hydrofining.

(2) Process cooling primarily by aerial condensers.

(3) Raw shale - 30 GPT: processed shale wetted with 20% water for compaction.

	Net Water Consumed Cubic Ft/Sec.
Mining[a]	0.3 - 0.4
Crushing (dust control)[a]	0.2 - 0.3
Retorting[a]	0.8 - 1.0
Processed Shale Disposal[a]	3.4 - 5.8[b]
Shale Oil Upgrading	2.0 - 2.5
Other (Personnel, construction, etc.)	0.1 - 0.6
TOTAL	6.8 -10.6

[a] In situ operation would eliminate most of these water requirements.
[b] If slurry disposal were to be used, this maximum could be as high as 7.0 cu. ft./sec.

Source: Man, Materials, and Environment, NAS, 1973

primary metals) accounted for 90% of total water withdrawals.

Water withdrawals for manufacturing are a function of the gross water demand and the recirculation rates that are employed within the plants. Recirculation rates are, in turn, influenced by the availability of water, water quality requirements for manufacturing operations, water costs, treatment costs, and effluent discharge requirements. Table 3 projects improvements in the rates of recirculation similar to those observed among manufacturers in the period 1954 to 1963, and indicates that water withdrawals per unit of production will decrease.

However, the more stringent treatment requirements for effluents are likely to cause manufacturers to recirculate and reuse water and treated effluents at higher rates than indicated in Table 3. High costs for effluent treatment, which produces waste streams of a quality suitable for inplant reuse, prompt the adoption of higher recirculation rates to optimize costs and reduce liability for plant discharges. With current technology, the average recirculation rates for the manufacturing sector could reach 8 to 10 times by the year 2000.

Table 3. Projected manufacturing water requirements in the conterminous United States

	1965	1968	1980	2000
Gross	90.0	97.7	164.3	349
Recirculation ratio	2.25	2.31	3.0	4.4
Withdrawal	40.0	42.3	54.8	80
Discharge	37.4	39.0	50.2	70
Consumption	2.6	3.3	4.6	10

Source: National Commission on Materials Policy Report, June 1973

RENEWABLE RESOURCES AND WATER QUALITY

The acquisition of a renewable resource can also cause unique impacts on water quality. The impacts associated with improper applications of forest practices include:

1. Quantity and timing of water runoff
2. Soil disturbance
3. Changes in stream temperature
4. Changes in chemical water quality
5. Pesticide and fertilizer effluents

Quantity and Timing of Water Runoff

Timber cutting increases water yields because evapotranspirative losses are reduced when trees are cut down. Silvicultural practices that lead to even-aged management and that include a period of complete stand removal have a greater influence on short-term water yield than do practices that involve uneven-aged management and only partial cutting. Reforestation usually decreases water yield, and converting vegetation from one species to another also causes significant changes in flow.

Flood runoff is also increased by deforestation. A stream channel is approximately filled by the mean annual flood. If the mean annual flood is increased following clearcutting, the increased discharge is accommodated by increased size of the channel. Most of the accommodation is made by increasing the channel width, implying extensive bank erosion, and possibly undercutting of sideslopes, roads, or other structures.

Soil Disturbance

Various forest manipulations may induce substantial movement of soil and associated nutrients which can eventually enter the waterways. The stripping of forest cover and the burning of vegetative soil, with attendant accelerated erosion and increased transport of sediment in streams, occur as a consequence of natural disturbance such as fire, windrow, disease and insect attacks as well as timber harvesting. Clearcutting substantially accelerates these processes. The amount of acceleration is partly a function of topographic, soil, and precipitation conditions, and partly a function of the total extent of initial disturbance, whether by tree cutting itself or by construction of timber extraction roads.

Impact of Forest Practices on Stream Temperature

Some forest manipulations bring about temporary changes in the temperature of the water in streams, lakes and estuaries. This environmental impact can result in changes in the biota for which these bodies of water provide a natural habitat. For example, increased water temperature in breeding areas is one of several ways in which pressure has been put on the salmon of the Northwest. Salmon, like other sport fish, have limited tolerance to variation in the temperature of their stream habitat. These limits have been exceeded in substantial bodies of water in the past.

Impact of Forest Practices on Chemical Water Quality

Most plant nutrients are stored in the soil in various degrees of availability to plants. The remaining nutrients are in the organic compounds of the forest vegetation and forest floor debris and are constantly being exchanged and recycled with the nutrient pool of soil. Under undisturbed conditions, the export of nutrients from a forest ecosystem often is low with respect to total turnover rates.

Harvesting practices upset this nutrient cycling process in several ways. First, they tax the conservation capacity of the soil by the sudden nutrient release from decomposing logging debris which results in a first-year fluctuation larger than the normal seasonal fluctuations in stream ecology. Second, burning of slash returns nitrogen and other volatiles to the atmosphere, and leaves a residue of nutrients in a highly mobile state in the ash. Leaching and erosion of the structureless ash occurs readily, contributing to the chemical content of runoff. Third, the export of logs and bark results in a nutrient loss from the production site, and generates a disposal problem at the processing site which contributes to water pollution.

Pesticide and Fertilizer Effluent in Water Courses

Herbicides are used in forest manipulations to control brush and to modify species mixes in favor of commercially desirable species. They are also used to control weed and brush growth along forest road rights-of-way. Residues from such herbicide applications can enter water courses, lakes and estuaries.

Forest fertilization is a rapidly developing technology used to increase the growth potential of forest land. In the application of fertilizers, some fraction of the chemical ends up off target. Aerial applications result in deposit across critical boundaries. Such introduction of nutrient additives into water courses can improve water habitat for aquatic organisms where streams are very low in nutrient content, or overenrich aquatic habitats and downstream receiving waters with possible subsequent increase in the rate of eutrophication.

Insecticide and pesticide residues can cross critical boundaries--a serious consideration since they are not selective with respect to nontarget species. They can therefore bring changes or death to water fauna or nontarget populations such as fish and insects.

RESOURCE TRENDS

Having demonstrated that water quality is indeed affected by some of the resource acquisition activities, it is important to evaluate the past and future patterns of the materials supplies and demands in general. The future effect on water quality will greatly depend upon the amounts of materials that flow through the materials cycle.

As shown in Figure 1, the United States has evolved from a basic agricultural and manufacturing economy in the early decades of this century to a more mature service-oriented economy in recent decades. Requirements and supplies of mineral materials kept pace with population growth despite wars and recessions. The faster rise of gross national product since 1940 reflects the increase in services and the amenities of life in the United States.

During 1972 the United States required about 4.4 billion tons of new basic mineral and non-food organic materials (Figure 2). This is equivalent to about 42,500 lb. per person. The sizes of the rectangles within the square indicate the proportionate weight of each type of material required per capita.

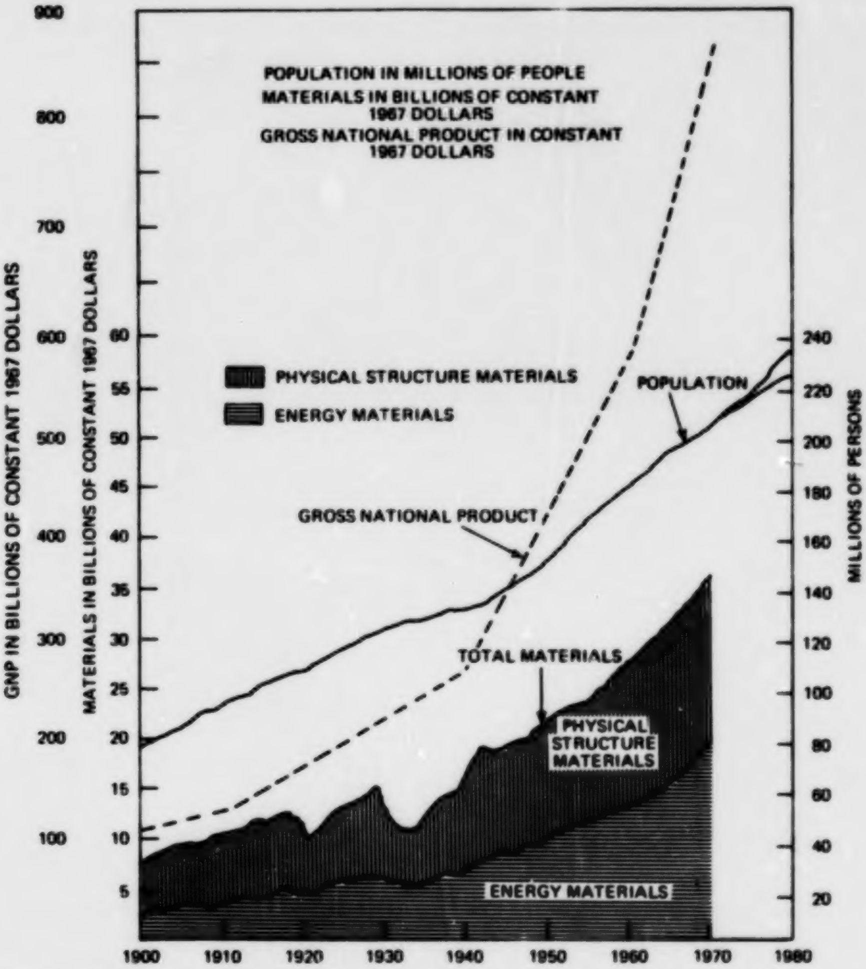

Figure 1. Raw Materials in the U. S. Economy: 1900-1969

Source: National Commission on Materials Policy Report, June 1973

Note that nonmetallic materials and mineral fuels predominate by weight.

Per Figure 3 it is noted that

- World consumption of raw steel, aluminum, copper, and zinc increased more rapidly during 1972 than consumption during the 1950-1970 period.
- The strong lead which the U. S. had over other industrialized nations of the world in the early '50s has diminished.
- The position of the U. S. as predominant producer of metals, minerals, and fuels declined considerably from 1950-1970.
- The U. S. mine production of major metals, nonmetals, and mineral fuels did not rise significantly from 1950-1970, and was certainly not proportionate to U. S. consumption or world consumption.

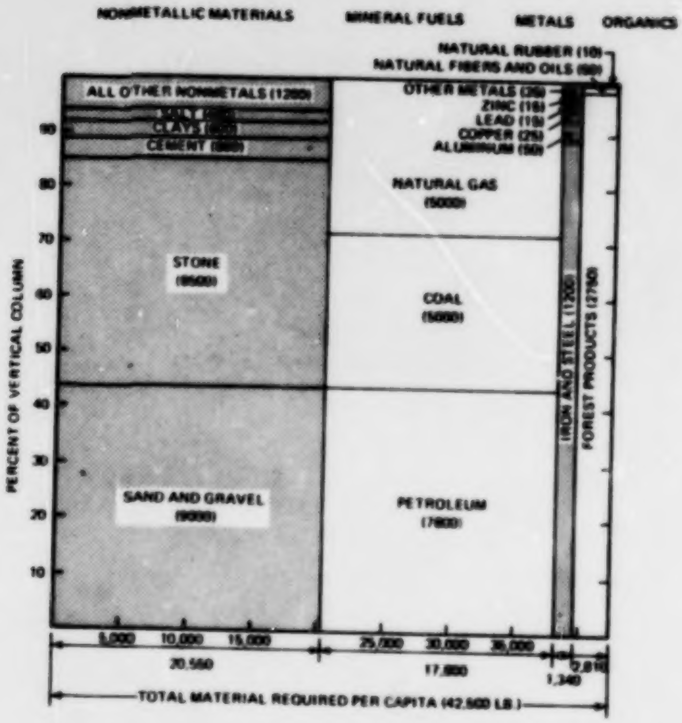

Figure 2. Weight of New Basic Raw Materials Required by Average U. S. Citizen During 1972

Source: National Commission on Materials Policy Report, June 1973

Fibrous materials consumed in the manufacture of paper and board is projected to total more than 150 million tons annually by the year 2000 (Figure 4). The U. S. demand for metals from now until the year 2000 will be great, with U. S. mine production not being able to meet the the demand (Figure 5). Consequently, the demand will be met by imported ores and concentrates, new and old scrap, and metal imports. However, it must be noted that the world demand for minerals and metals will increase more than that of the U. S. Competition to obtain resources in the foreign marketplaces will be high -- greater than the U. S. has ever faced.

Given the above resource trends and the present level of technology, population trends, and consumptive habits, it is reasonable to expect that more materials will pass through the U. S. materials cycle in the next decade. Consequently, the environmental stress per unit of production on water quality will increase as (1) the quality of ores and other natural resources declines, (2) the readily available resources are exhausted, and (3) the use of energy per unit of output increases to maintain the intensity of materials throughput.

In summary, since the environment is both the source of materials and the sink for the waste or byproducts of production and use, materials and environment interact continually. The continuing yield of materials and quality of water will depend on how materials are extracted, how materials are re-

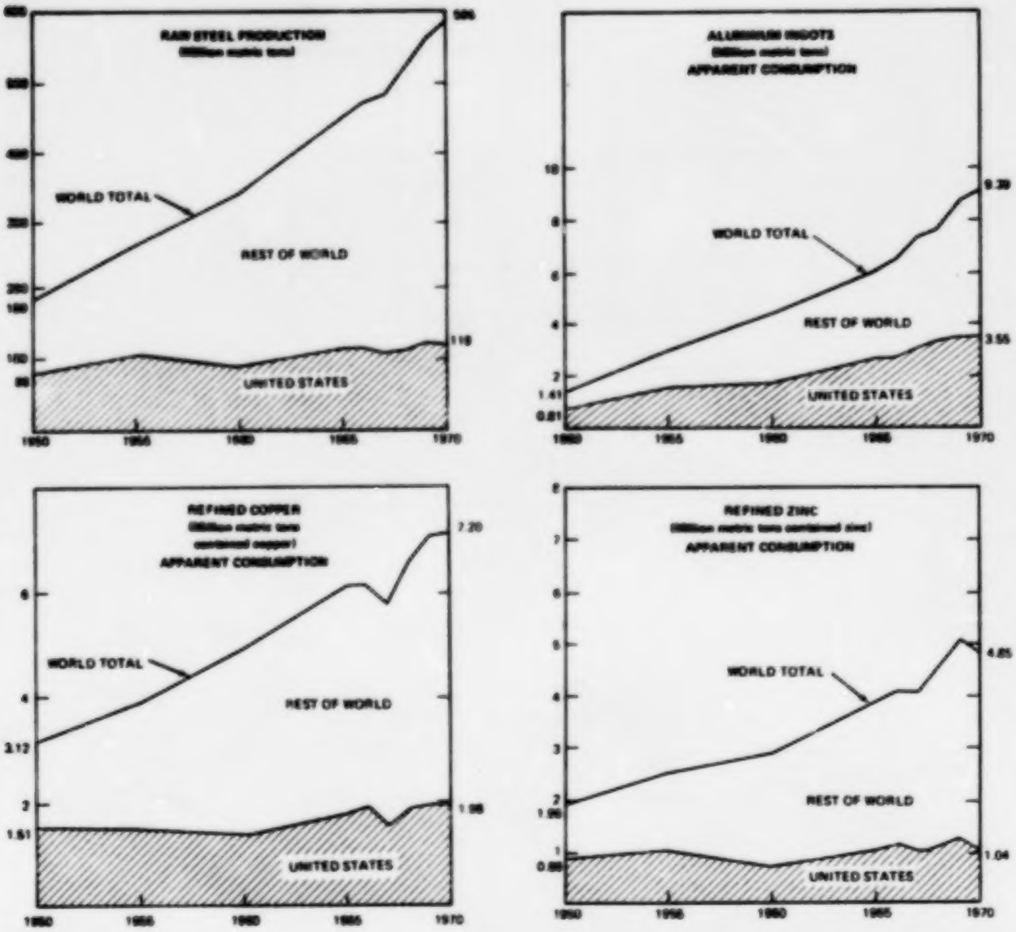

Figure 3. World Metal Requirements Compared with U. S. Needs

Source: Second NCMP Interim Report, April 1972

stored to the environment, how water is used, how much is consumed, and how it is treated. No stage of the materials flow system can be treated without regard for the others; actions at one point of the system always affect many others. The challenge to those who frame policies is to acquire an understanding of the basic interactions in the materials and water systems sufficient to obtain the desired outcome and avoid unwanted effects.

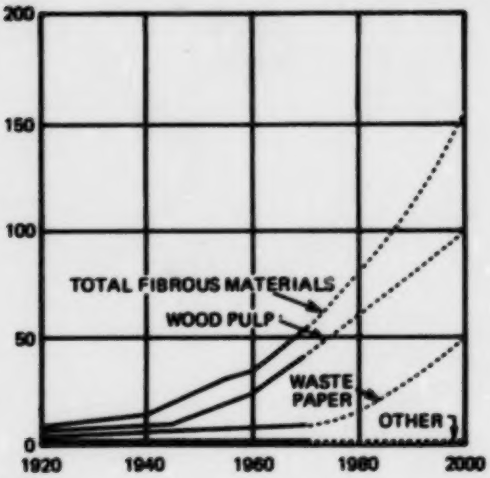

Figure 4. Fibrous Materials Consumption in the U. S. to the Year 2000.

Source: NCMP Report, "Timber - The Renewable Material," 1973

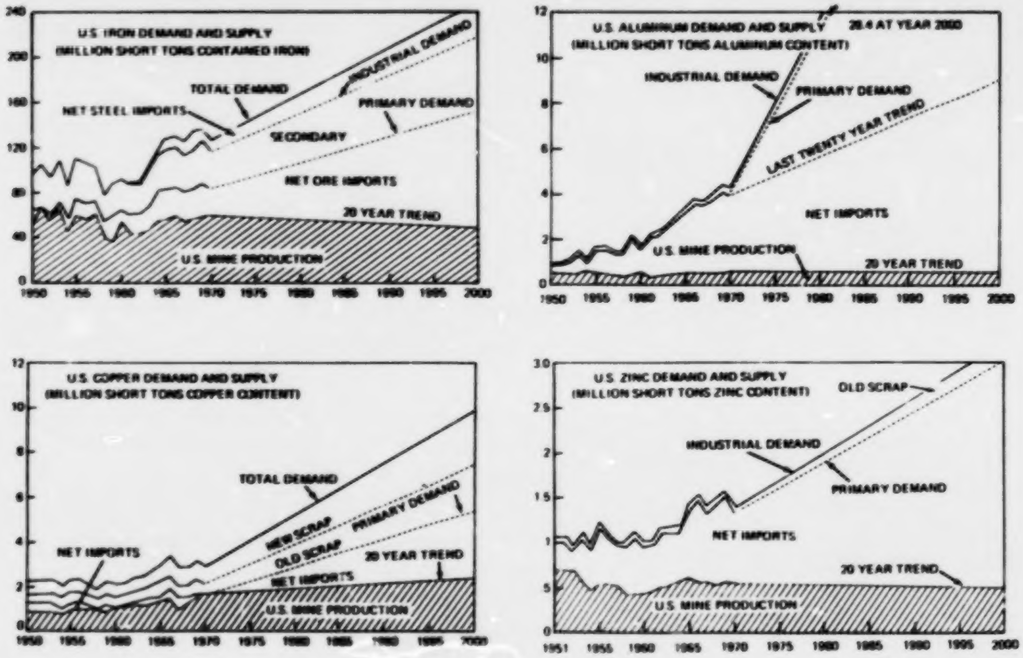

Figure 5. Demand and Supply of Major Metals in the U. S. to the Year 2000

Source: National Commission on Materials Policy Report, June 1973

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THE IMPACT OF ENERGY SELF-SUFFICIENCY ON POLLUTION CONTROL

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ABSTRACT

This presentation will initially describe the general role of environmental research and specifically that of the EPA in the achievement of energy self-sufficiency. This role is based on the Federal position that the development and implementation of energy technology and policy must be sensitive to effects on health and the environment. If this sensitivity is rationally incorporated into the energy development process, self-sufficiency can be achieved in harmony with the environment. The fundamental goals of the Federal energy-related research program are therefore to: (1) fundamentally improve understanding of the environmental impact of energy self-sufficiency; (2) determine the relationship between source control and impact reduction on social, economic and environmental terms; and (3) translate these research efforts in a manner which permits the public and its representatives to make policy decisions based on knowledge of the total costs and benefits of various approaches to energy self-sufficiency.

The second portion of the presentation will summarize the major environmental problems in the achievement of energy self-sufficiency and the corresponding Federal environmental research objectives designed to solve these problems. These objectives and associated resource allocations, based on a $191 million increase in the FY '75 research appropriation, will be described in terms of seven major environmental research program areas.

INTRODUCTION

Public concern for the health, environmental, societal and welfare impacts of energy-related activities has become the single most important issue limiting the growth of domestic energy production. These public concerns are directed at observable as well as suspected deleterious aspects of the discovery, extraction, transport and processing of fuels as well as their conversion to produce synthetic fuels.

These concerns are ligitimate, urgent, and unavoidable. They dictate that health and environmental considerations be integrated with the large-scale technological developments associated with the achievement of energy self-sufficiency. They demand that a broadly based vigorous and effective program be conducted in parallel with and closely coupled to the technology R&D to guarantee minimal effects on man and his environment.

Our growing environmental concerns and most recently the energy crisis have combined with gathering force to make us understand that we do not have unlimited room or resources. We are starting to see that our energy and environmental ills stem, essentially, from the same source: from patterns of growth and development that waste our energy resources just as liberally as they lay waste our natural environment. We no longer live in a time when we were few and the land was wide and waiting for us. We have reached the point where we can no longer insulate ourselves from the punishment and pollution we visit upon the earth and the atmosphere, and where the natural resources we once regarded as so endlessly available and expendable are becoming increasingly hard to get.

The energy crisis is part and parcel of our overall environmental problem -- a classic symptom of the strains that occur when an organism begins to exceed the carrying capacity of its habitat. It warns us that we had better begin to face up to the fact that modern man everywhere is pressing the limits of the resources and resilience of the earth.

This environmental research agenda is designed, therefore, as an integral part of the energy R&D program in order to improve understanding of 1) the impact of energy self-sufficiency on human health welfare and ecological systems and 2) the relationship between source control and impact reduction. This understanding must be gained and applied in concert with the achievement of energy self-sufficiency if this policy is to be protective of human health and the environment. Further, this understanding must span all phases of the energy cycle from extraction through conversion to end utilization as well as the environmental relationships existing between these phases.

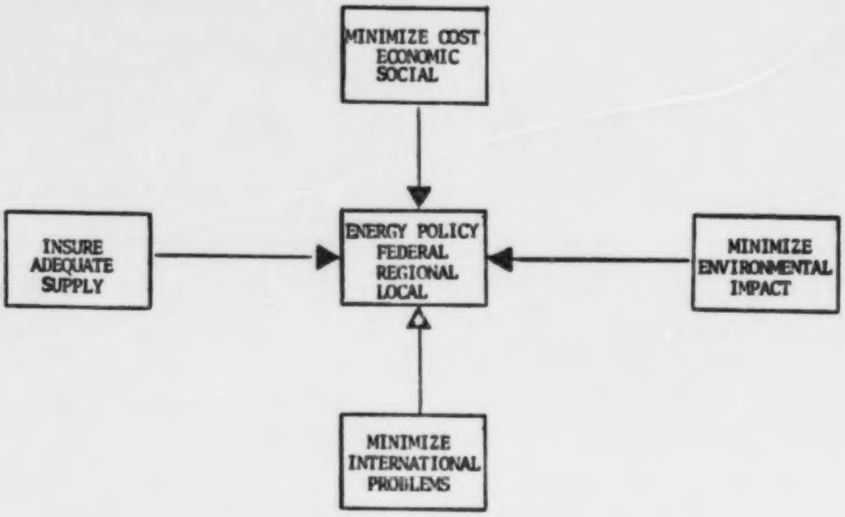
The scope and objective of this research program consider the activities necessary to define in timely and cost efficient manner the environmental control requirements which will complement the future production of energy.

The difficulties in energy related decision making are nowhere more evident than those relating to the environment. Explicit consideration of the environmental imperative is a new, often a first glance, constraining concept in the development of energy and associated R&D policy. In addition, the basic information upon which to base these energy decisions is very often either non-existent or of a qualitative and emotional nature intended to support adversary positions rather than resolve apparent conflicts between energy and the environment.

As shown in Figure 1, energy policy formulation on the Federal, regional or state level appears to take the obvious benefit goals of providing adequate supplies, minimum cost and maximum use of domestic resources and adds the apparent conflicting goals of minimum environmental impact. However, if the environmental goal can be considered integral with energy policy formulation and supported on a sound technology and policy base, it may cease to become an apparent conflict issue.

It is basic to the practical achievement of an energy policy, praticularly one of energy self-sufficiency, that data limitations relating to the environment be removed and an environmental/energy policy relationship such as that shown in Figure 2 established. This relationship will allow the adequate consideration of environmental protection costs and benefits in the formulation of energy policy.

At the present time the environmental data base is effectively limited to characterization of an aggregated subset of fossil and nuclear energy residuals and definition of the health effect thresholds associated with a few major energy related air pollutants within this subse of residuals. A number of additional energy residuals whose environmental impacts have not yet been quantitatively examined can be expected to have as great an additional effect on the development, implementation, siting and control of energy systems as that already, for example, caused by sulfur oxides. These include fine particulate and associated trace metals; sulfate aerosols; Krypton-85, Strontium-89, tritium; waste heat; solid wastes and associated water pollutants from mining, processing, conversion and control as well as destructive land use. The objectives of this environmental research agenda are directed to obtaining the priority impact and transport data concurrent with the development of energy self-sufficiency. In this fundamental objective, control requirements can be defined as an integral part of the basic energy development program rather


MINIMIZE COST
ECONOMIC
SOCIAL
INSURE
ADEQUATE
SUPPLY
ENERGY POLICY
FEDERAL
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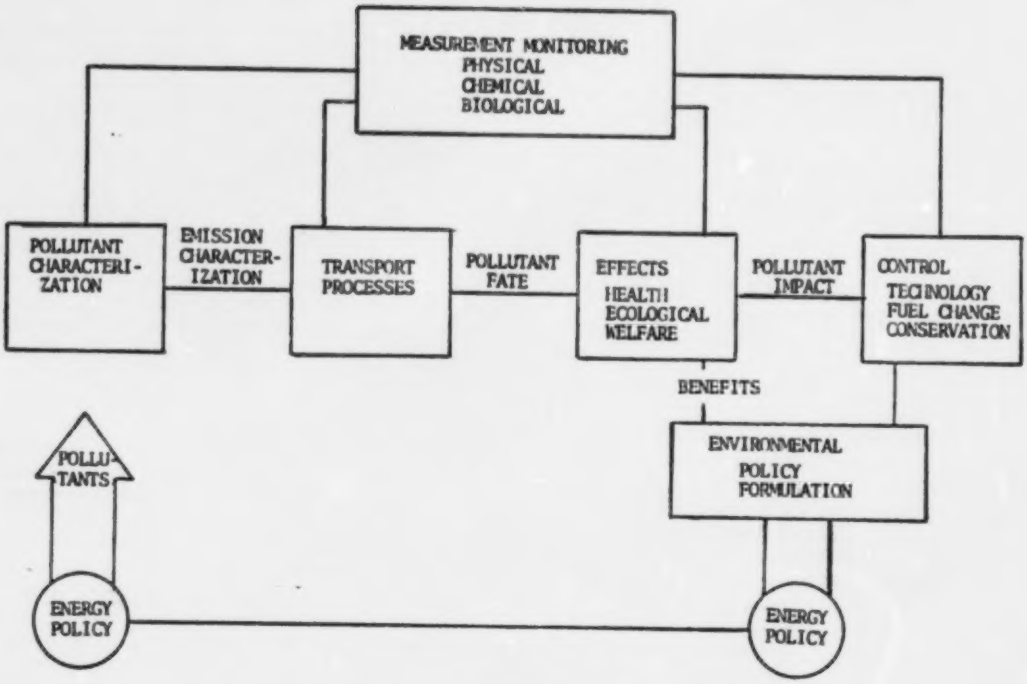
INTERNATIONAL
PROBLEMS

Figure 1. Energy Policy Formulation


MEASUREMENT MONITORING
PHYSICAL
CHEMICAL
BIOLOGICAL
POLLUTANT
CHARACTERIZATION
EMISSION
CHARACTERIZATION
TRANSPORT
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FATE
EFFECTS
HEALTH
ECOLOGICAL
WELFARE
POLLUTANT
IMPACT
CONTROL
TECHNOLOGY
FUEL CHANGE
CONSERVATION
BENEFITS
ENVIRONMENTAL
POLICY
FORMULATION
POLLUTANTS
ENERGY
POLICY
ENERGY
POLICY

Figure 2. Environmental Data Flow

than later retrofitted at much greater economic cost, industrial resistance and reduced environmental and operational efficiency.

In order to achieve energy self-sufficiency at known and acceptable environmental and economic cost, there is, therefore, a pressing immediate need to clearly understand the health, welfare and ecosystem dose-response relationships for all established and potentially hazardous energy residuals. Supporting this goal must be comprehensive capabilities to identify, measure and monitor each of these residuals, both at the source and in the ambient environment and to understand the transport processes by which these residuals transform and move through the media and biota to their ultimate fate or receptor so that source control requirements can be rationally defined for public and industrial understanding and acceptance.

Another immediate factor magnifying the environmental data and assessment methodology necessary to guide the development and implementation of new energy sources and technologies is the demands of Environmental Impact Statements directed by NEPA and recent court decisions directing clarification of the environmental regulatory process and the threshold concept of standard setting. These include definition of "significant" environmental quality degradation at levels well below current environmental standards. This definition will have a particularly fundamental impact on the developing and siting of new coal based energy technologies. These new data requirements are the first steps in what clearly will be the long-term mission of enviornmental research. This long-term mission will move from the purely Federal regulartory response to idenfitied problems and will shift toward a strategy of prevention based on better understanding of local environmental effects relative to the costs of reducing these effects and a firmer insight into the impact of broad social goals and energy policies on environmental quality. The public must be provided the capability to make the decisions as to whether or not to pay these "costs". The accomplishment of these long-term goals will, ththerefore, require that local governments and industries establish the capability to examine realistically the possible alternative energy strategies available to them. The responsibility of the Federal Government in this context is to 1) support the development of the data base, tools and methodologies that make such examinations possible and 2) provide broad assessments that consider the total energy cycle and thus provide the framework and basis for rational decisions leading to the local prevention of environmental degradation. These local decisions, when aggregared, will best approach an optimal rational environmental control strategy for energy.

In summary, two basic conclusions have been drawn with respect to this challenge: first, development and implementation of energy systems for achieving and maintaining energy self-sufficiency clearly must be sensitive to the effects that the systems will have on health, welfare and ecosystems. Second, if this sensitivity is rationally incorporated into the development and implementation of energy processes domestic resources can be broadly utilized harmony with the environment.

The achievement of this second point is the fundamental goal to which this environmental research agenda is directed. This agenda consists of five subprogram constructed by projecting presently known and anticipated concerns for the impacts of existing and developmental energy systems on the environment and the prevention or control of these impacts. These subprograms are directed at research in the areas of 1) Effects (Health, Ecological and Welfare), 2) Instrumentation and Monitoring, 3) Environmental Processes, 4) Control Technology and 5) Implementation.

Goals and Objectives to be Achieved During the Next Five Years

Pollutant Characterization, Measurement and Monitoring - Goals:

To identify and define the chemical and physical characteristics of the by-products associated with each phase of existing and developing energy systems from extraction through utilization of the energy and to achieve a capability to accurately measure and maintain an accounting of the total impact of these pollutants on existing and developing energy systems on heuman health, welfare, society, and ecological systems.

The starting point for any environmental evaluation of energy systems is characterization of the physical and chemical properties of energy system residuals which result in all phases from extraction through conversion and transmission to end utilization. This characterization must also consider the technologies used to control pollutants and the residuals which result from the control processes. The importance of this knowledge of the material balances of each energy system is the guidance it provided to both the effects and control R&D. Instrumentation and analytical techniques must be made available to perform this characterization throughout the development of new and improved energy systems as well as to maintain an accurate accounting of these residuals and associated control performance after commercial implementation. Finally, monitoring systems must be developed and implemented on a national and even international scale to provide the capability to accurately measure the impact of all energy-related pollutants on human health, welfare, society and localized ecological systems. This measurement capability is fundamental to the development of national environmental standards and incentives. These systems must further be capable of maintaining an accounting for their impacts to insure that they are maintained below tthe defined tolerance levels.

The projects included in this program are those in which funding is imperative to meet the near term requirements of the 1972 Noise Control Act, the Clean Air Act and the Federal Water Quality Act (1972) as they bear on energy systems.

The primary objectives of the research in the FY 75-79 period are as follows:

Characterization

- Develop and apply all methods necessary to chemically and physically quantify the residuals associated with existing and developmental total energy systems and technologies.

Monitoring and Measurement

- Insure precision and accuracy of ambient and source measurement methods and procedures for criteria and radiological pollutants.

-Develop verified ambient and source measurement methods and procedures for pollutants for which no standard has been established (e.g., fine particulates, sulfate, nitrate).

-Develop quality assurance procedures and training programs for monitoring environmental degradation.

-Develop and demonstrate advanced monitoring techniques, i.e., remote/in situ sensors.

-Develop and implement data acquisition, retrieval, and assessment procedures permitting maximum Federal, regional and local application of monitoring information.

-Develop physical standards for calibration of instrumentation used to measure pollutant concentrations.

Environmental Transport Processes - Goals:

To determine the relationship existing between energy system byproduct emission burdens and ambient environmental concentrations as well as trace the pathways from energy system emitter to ultimate fate.

The second step in the sequence of environmental data development is understanding and being able to predict the relationship between energy system emissions and the ambient concentrations affecting the environment. Decisions on the best approaches for allowing energy growth while balancing existing and potential environmental quality conditions are to a large extent perplexing because of our inadequate knowledge of the transport, interactions and fates of pollutants. In order to satisfy this requirement, the capability must be developed to trace the pathways and transformation of energy system emissions through all media and biota to their ultimate fate or receptor. Transport processes encompass two classes of phenomena: physical transport and chemical transformation.

Transport processes are important in three regions: immediate neighborhood of the source; regional; and global. Chemical transformations of pollutants occur both in the atmosphere and water. In these cases relatively innocuous compounds may be converted into more toxic and more damaging species.

Specific priority research objectives to be pursued in the FY 75-79 time period include:

1. Atmosphere
    a. Cooling System Plume Behavior.

    b. Atmospheric interactions in both Dry and Wet-scrubbed plumes from Fossil Energy Systems (especially respirable sulfate particle formation, SO_2 oxidation rate, and interactions with urban pollutants).

    c. Dispersion of Plumes in Rough Terrain.

    d. Low-level Dispersion pathways and ultimate fates of Radionuclides from Nuclear Plant Building Releases, especially at low wind speeds and including building wake effects.

2. Freshwater
    a. Thermal and pollutant dispersion pathways and ultimate fates in streams, lakes, and groundwaters.

    b. Physical and chemical transformation of pollutants in streams and lakes.

3. Marine
    a. Thermal and pollutant diffusion in characteristic coastal waters.

    b. Physical and chemical transformation of pollution in coastal waters.

4. Intermedia
    a. Transfer of atmospheric sulfur to soils and economic crops.

    b. Impact of moisture and heat release on local climate.

    c. Model for precipitation scavenging of sulfur.

    d. Dry deposition of atmospheric pollutants.

Effects: Health, Ecological, Welfare and Social - Goals:

To define the health, welfare and social and ecological effects of existing energy systems, to obtain adequate information on the parameters of social and economic changes resulting from environmental modifications associated with energy systems and to develop sufficient information on the damage functions associated with developing energy systems to confidently permit assessment and control.

Health Effects

It is clear that while existing data are adequate to define a risk to health and hence indicate the need for control, an adequate appreciation of the true health impact for energy system related pollutants does not exist. Sufficient effort has not been made to determine the nature of the dose response relationship with respect to numerous important end points. For example, although existing data are sufficient to define the need for a total suspended particulate standard, they are not adequate to evaluate the impact of particle size or chemical composition of these particles upon health. Likewise, in the case of carbon monoxide, data do not exist to define the effect of CO upon the very young, especially premature infants and little information is available to determine the effect of high altitude upon response to carbon monoxide. The standard for NO_2 is based, perhaps, upon the least sufficient information of all existing standards. While minimally adequate toxicologic data indicate that NO_2 is a problem, epidemiologic and clinical studies do not exist to adequately define important dose-response relationships. These deficiencies are compounded by measurement method problems which have unduly confounded even existing studies.

This problem will provide limited but urgently needed information on health effects required for safe utilization of energy systems. Information will be obtained from clinical and epidemiologic studies on human populations and limited experimental studies on animals and lower organisms. It will be possible to initiate minimal but less than adequate studies on short and long term effects of acute, chronic and intermittent exposure to energy-related pollutants on which criteria for standards must be based ultimately. On late effects studies, end points of particular concern will be obtained on carcinogenesis, mutagenesis, teratogenesis, and physiologic and metabolic effects. Again, with minimal funding, studies of the complex problems of potential synergistic effects of simultaneous exposure to more than one pollutant cannot be conducted. Minimal efforts will be directed to the combating of adverse effects of pollutants in man. Studies will include investigations on those pollutants for which standards are required by law, studies of some of the other known pollutants, and identification and evaluation of other possible toxic materials resulting from energy systems. As indicated, the level of activity will be lower than desired in all areas in the "Orderly" program, and work on all but the primary and secondary pollutants will be drastically reduced.

Specific priority health effect objectives supporting energy self-sufficiency which must be addressed in the FY 75-79 time period are:

-Strengthening of scientific bases for existing primary ambient air quality standards. Although these standards were formulated upon the best available information at the time of their promulgation, there is a pressing need for the Agency to place these standards on as firm a scientific basis as possible before they are implemented. Gaps in knowledge are particularly evident with respect to nitrogen dioxide.

-Evaluation of health effects associated with exposures to air pollutants for which ambient air quality standards do not presently exist. These include effects of fine particulates and suspended sulfates, as well as known or suspended carcinogenic hydrocarbons (PPOM).

-Health effects associated with exposures to trace metals and persistent chemicals. Although these are in reality multi-media problems, airborne exposures can be important. Current strategies for long term control of lead mobile source emissions and for control of lead and cadmium stationary source emissions are dependent upon availability of additional health effects information.

-Evaluation of health consequences resulting from the impact of fuels and fuel additives upon regulated as well as non-regulated pollutants. Work includes safety assessment of catalysts to be used in emission control systems for automobiles as well as protocol development for safety assurance testing.

-Definition of effects of simultaneous exposure to a number of air pollutants. This includes assessment of non-pulmonary effects due to air pollution such as decreased resistance to infection, and impact upon health of future generations via teratogenic or mutagenic effects.

-Detection of long term, low level effects of pollutants (including radiation).

-Development of means of combating adverse effects of pollutants.

-Provision of information on health effects essential to cost-benefit-risk decisions in the choice of energy systems when diverse, competing technologies exist.

Ecological Effects

The general objectives of ecological effects research are: (a) to assess the effects on ecosystems of various steps in the fuel cycle; (b) to provide feedback information to the technologies so that appropriate controls may be instituted; (c) to develop information complete enough for cost-risk-benefit comparisons of alternate energy technologies, and for the development of new environmental management techniques to minimize ecosystem impact including the impact of habitat obliteration and secondary development in estuarine and wet-lands habitats brought about by energy-related installations.

In the ecological effects area the base of fundamental knowledge in the structure and function of ecosystems is too inadequate to predict and interpret the impact of introduced insults. The limited resources available to energy effects research has necessarily required that first priority be placed on the human health aspects of energy residuals. As a result energy technologies intended to produce synthetic oil and gas from coal are being considered as "clean" only in terms of their ability to minimize the air pollution potential associated with coal combustion. While this consideration for the primary health impact of coal in urban areas is a necessary factor in energy system design, it is by no means sufficient to ensure the environmental harmony of energy self-sufficiency. Major ecological and obvious degradation of land as well as surface and groundwaters. These concerns have been largely limited by available data to the subjective. Little or no effort has been made to understand the ecological impact of these operations, both immediate as well as the more subtle changes that ultimately could seriously affect the natural ecological balance thus limiting man's ability to survive on this planet.

It must be clearly understood, for example, that the inherent inefficiency of coal conversion technology coupled with the use of chemical additives to remove air pollution increases, in a quantitative sense, destructive land use by at least 30 percent and solid waste and the resulting water pollution potential by more than 70 percent relative to direct coal combustion systems. Further, the demands of energy self-sufficiency mean that U.S. coal production will triple from 600 million tons per year in 1973 to more than 1,800 tons by 1990. In a qualitative sense the introduction of new chemical species for air pollution control increases the damage potential of these residuals by an unknown degree. The immediate goal of the ecological effects research program is therefore to understand these impacts so that the distribution and control of rapidly increasing coal related energy residuals associated with energy self-sufficiency can be accomplished in (1) a manner which minimizes their ecological impact to a level consistent with local tolerances and (2) without jeopardizing the health effects control capability of these emerging energy technologies.

Development of new coal technology must be done in a manner minimizing environmental and ecosystem damage. This research program will insure that energy self-sufficiency can be attained by 1985 with known and controllable environmental impact. Ecological impact and ecosystem data on oil shale and geothermal technology will not be initiated under this level of effort until 1978-79. Specific objectives to be addressed in the FY 75-79 time period are:

1. Assess the environmental effects and impacts of coal, oil, oil shale, uranium, and geothermal extraction techniques and predict ecosystem effects permitting enhancement of benefit-cost ratios by suitable land management policy.

2. Determine the environmental effects of radionuclides, hydrocarbons and other fuel transport and storage. This will include determining the accumulation ratios and transfer rates of secondary pollutant dispersal through the food chains and other pathways, and development of strategies for concentration and/or decontamination in order to minimize residual long term ecosystem effects, including those impinging on man.

3. Determine pollutant pathways and toxicities so as to guide routine and non-routine releases from energy conversion and reprocessing plants. Both geochemical and ecosystem studies will be conducted to provide guidelines and criteria for siting of facilities and disposal of both liquid and solid wastes generated by both nuclear and non-nuclear plants.

4. Determine the ecosystem costs of thermal shocks from power plant waste heat release, from entrainment and impingement in the cooling systems and from cooling tower blow-down as well as the impact of anti-fouling additives. Additionally, the ecosystem impacts and synergistic effects of effluents such as radioactive materials, trace metals, noxious gases, organic compounds and other substances produced during energy generation will be evaluated and management strategies instituted for minimizing these impacts.

5. Develop biological indices (species diversity, fecundity, natality, mortality, etc.) for ecosystem impact evaluation. A systems approach encompassing laboratory, greenhouse, microcosm, and large scale field experimentation will be used to address the problem. This systems approach requires a model that is structured in such a way that those subsystems most affected by pollution can be sensed. A more detailed analysis of these

components will then be made with a view to assessing the site, time, and mechanism of the pollution effects.

6. Conduct large scale ecosystem studies on dedicated, controlled-access parcels of land and water, such as environmental research parks, and through the biome studies developed under the International Biological Program.

7. Produce a number of relatively simple, reliable estimators of ecological impact and estimated extent and duration of observed effects using the above capabilities and data base.

Social and Welfare Effects

Social effect studies will quantify both tangible and intangible costs of selected energy projects. Economic methods and protocols will emphasize not only the direct costs to energy consumers, but also indirect or hidden dollar costs; e.g., to taxpayers. Sociological methods will develop a standard protocol for estimating non-dollar costs as well. With minimal funding particular case studies can be started, including land use changes, documented with a social segment in the regional data base; regional modeling for predicting social changes can be started only very slowly.

Welfare effects, in a special sense defined by the Clean Air Act, includes damage of pollutants to materials from fossil fuel systems; indirect effects (savings) in this area and others should arise from nuclear systems and unconventional alternatives.

The minimal program would establish a capability for the evaluation of the effects of atmospheric pollutants (acid rain) on national memorials, public buildings, works of art, and irreplaceable structures.

Effects of extraction processes on land for any fuel cycle have aspects of public welfare which need research as an input to Assessment and Policy Formulation.

Specific objectives to be addressed in the FY 75-79 time period are:

-Assessment of material deterioration problems in field at present.

-Factors effecting erosion of stone - characterization and parametric evaluation.

-Study of pigment degradation in artistic and other works.

-Assessment of contruction metals and their uses in construction, art and transportation.

-Develop a reasonable standard protocol for societal assessment techniques to be used by different energy R&D groups (opinion surveys, handbooks, etc.).

-Develop and test models of value changes in impact assessments. Compare results of system analyses used by all groups.

-Implementation and dissemination of results (in lay terms) to government policy-making bodies, etc.

Environmental Assessment and Policy Formulation - Goals:

To provide mechanisms for rationally integrating environmental considerations into the energy policy decision making process. These mechanisms must include (1) evaluation of the institutional, economic, sociological, and technical implications of environmental impacts and controls, (2) development of information synthesis methodologies for determining cost/benefit and other relationships; and (3) analyses of alternative energy systems using these tools with development of recommendations for optimal energy policies compatible with environmental and public health goals.

Energy issues are inextricably interwoven with all aspects of the modern society from economics, and environment to its very life style. Any major change affecting the terms and conditions under which energy is produced, distributed or consumed impacts in many, varied and often unpredictable ways throughout all segments of the society affecting the way people work, live, and spend their leisure time. Furthermore, the effect is often non-uniform with respect to regions of the country and with the population. For example, an attempt to produce "clean" energy for urban areas can adversely impact already "clean" rural areas by disrupting the land, air and water environment previously used for agriculture. This impact can in turn impact the population in urban areas through higher food costs.

Energy issues also affect international politics, national security, and international balance of trade. It is probably fair to say that no other single sector of the economy has such pervasive efforts on all aspects of life.

The Implementation Research objectives are directed at providing the basic knowledge to define the constraints imposed on energy systems when applying appropriate environmental impacts; and means for preventing, controlling or avoiding environmental insults. While all of these areas are essential for developing and implementing a sound national energy policy, they are not sufficient to identify and achieve an energy program that attempts to optimize all the societal costs, where both costs and benefits are viewed to include the full range of environmental, institutional, social and economic factors.

It would appear that the credits and debits of an energy system cannot be totaled on an accounting balance sheet. However, it would appear that an attempt should be made to provide the energy policy decision-makers, be it at the Federal, state, local or plant level, with better tools to weight the various institutional, economic, social and technological factors. In essence this is the purpose of implementation research.

Priority research objectives in the FY75-79 time period are:

-Determine the ability of existing and proposed institutional structures for energy decision-making to accurately represent the environmental concerns of all segments of the population.

-Development of methodologies for intercomparing the environmental risks and benefits of highly disparate energy systems.

-Research leading to improved quantification of both environmental costs and benefits to society and development of techniques by which the cost of pollution control can be more effectively internalized.

-Development of methodologies for synthesizing information produced by the environmental research programs.

-Analysis of alternative implementation techniques for reducing environmental impact (e.g., Environmental Impact Statements, Environmental Standards, economic incentives).

Control Technology Research

The objective of the control technology research agenda is to define the requirement for technology needed to reduce or inhibit environmental degradation associated with or potential to state-of-the-art or new energy system technologies. The environmental control research agenda is directed toward the development and demonstration of the technology necessary to achieve material energy self-sufficiency at a cost which is both environmentally and economically acceptable.

This is a particularly challenging objective because of the inherent environmental "dirtiness" of the domestic energy resources which are sufficient to meet our expanding energy needs in the near-term, specifically coal and shale oil.

The means for meeting this challenge include control process technology, fuel changing or modification, improved dispersion of residuals, land use planning to minimize environmental impact, basic energy process modification, and conservation to reduce energy demand.

The primary environmental control development requirements may be summarized as follows:

-Fine particle control for metals, sulfate and condensed organics.

-Improved sulfur oxide and nitrogen oxide control through fuel pretreatment as well as combustion modification and flue gas cleaning.

-Capability of "zero" discharge for water pollutants at all phases of the energy cycle.

-Waste heat use and dispersion.

-Land reclamation and subsidence control.

High Temperature Gas Turbine

High Temperature Turbine - Low BTU coal gasification, integrated with a high temperature turbine offers the potential for improved thermal efficiency in electrical generation. Aside from the need for essentially total particulate removal prior to the turbine, as discussed under Low BTU gasification, control of increased NO_x emissions caused by high temperature nitrogen fixation must also be addressed. Dry control methods for NO_x are needed if excessive water pollution and usage as well as turbiee efficiency degradation is to be avoided. The proposed control R&D program would address control of combustion reactions through combustor design followed by verification testing and demonstration as an integral part of the high temperature turbine development. This control technology will also have application to advanced automotive turbine development.

Advanced Cycles, Fuel Cells, and Other Concepts

Magnethohydrodynamics - Emissions of both sulfur oxides and nitrogen oxides will have to be controlled for both open- and closed- cycle processes operating with fossil fuels. In the open-cycle, demonstration of total ash and metallic seed material must be achieved. The most pressing control R&D requirements will be in the control of NOx at the very high temperatures and the application of fine particulate control developed for conventional combustion applications to the specific requirements of open-cycle MHD.

Use of Wastes as Fuels - Effort must be directed to the development and demonstration of pyrolysis techniques for producing solid, liquid and gaseous fuels from municipal solid wastes without the concurrent release of dangerous byproduct. Direct and mixed burning technology must be demonstrated on the range of industrial and utility combustion systems with specific gaseous and particulate air pollution control systems.

Advanced Auto Rail, Ship and Air Propulsion

Air pollution control R&D is required to (1) assess the emission characteristic of new engine system and alternative fuels and (2) develop design modifications and operating procedures to achieve emission control requirements.

Energy and Fuel Transmission Distribution and Storage

Control requirements focus primarily on the understanding and control of high voltage (HV) transmission system effects; zone noise and non-energy electromagnetic radiation. A second area of development is in improved leak detection add control devices for pipeline systems. The critical importance of this capability to the environmentally sound development of the Alaskan Pipeline make Federal involvement important to insure both timeliness and operational adequacy.

Increased Production of Oil and Gas

Of particular concern during oil and gas exploration are the accidental spillages and releases of brines and hydrocarbons that may occur from test drilling, both onshore and offshore. Efforts should also be directed to demonstrate the practical application of existing control techniques and to determine the operational adequacy of these techniques. Of particular need, as more emphasis is placed on offshore drilling, is improved techniques for flowout prevention as well as development and demonstration of baseline protection and nectoration methods for oil spills. Once the technology is developed it should be included as a requirement in offshore petroleum operations. A second major environmental need associated with both nuclear and non-nuclear stimulation and in situ oil shale retorting is the ability to predict, monitor, and control seismic and subsidence effects. A third control R&D need is the development and/or adaptation of technology for the removal of contaminants at the well head. These include: (1) nitrogen which is the major contaminant in much low-grade gas and (2) wasted natural gas at combined-oil and gas wells. This program is especially needed to demonstrate efficient and economical contaminant removal systems permitting recovery of natural gas from small individual wells.

In oil shale processing a program is required to characterize the environmental burdens associated with the various industry developed processing techniques and to develop and demonstrate the necessary environmental controls. Pollutants which will need to be considered include sulfur, nitrogen, particulates and hazardous trace metal air and water emissions, and the large solid waste emissions represented by the retorted shale.

Mining

Surface Mining - The thrust of the control technology research and development for surface mining of coal is to develop and demonstrate suitable methods for control of acid mine drainage and reclamation of the ground water system and land disturbed by mining operations. Research in soil stabilization is required to prevent erosion by water and wind. Further, the restoration of natural surface drainage and aquifers are necessary to minimize long term ground water effects.

Underground Mining - Control research in subsidence and acid mine drainage is vital if the vast underground deposits of coal are to be used in an environmentally acceptable manner. Annually, some 500 billion gallons of mine drainage containing millions of tons of acids, acid salts and alkali salts degrade over 10,000 miles of surface streams and more than 15,000 acres of impounded water. Further, subsidence problems and fires in abandoned mines and tailing piles create hazardous conditions which must be controlled.

Oil Shale Mining - With the expansion in use of oil shale, the land requirements and potential environmental burden caused by mining and spent shale disposal will be significant. Some of the potential environmental problems to which the control technology is addressed are:

-Lowering of water tables in the vicinity of the mine.

-Erosion and leaching of spent shale deposits.

-Worsening of water quality with time as mine depth are increased.

-Long term ecological system disruption resulting from inadequate land reclamation techniques.

Specific emphasis should be placed on the development of methods to minimize water utilization.

Direct Combustion

The first control technology which should be developed under this area is fluidized bed combustion of coal in the presence of limestone. The envisioned fluidized-bed boiler should permit combustion of high-sulfur U.S. coals for electric power generation with simultaneous control of SO_x and NO_x. Data indicate that, in comparison with uncontrolled conventional boilers, fluidized-bed boilers offer potential for 90 percent reduction in SO_x and major reduction in NO_x. Since even the dirtiest fuels can be handled, control can be effected without change in fuel type, quality or origin.

Ongoing development and demonstration of combustion modification techniques for the control of NO_x emission from conventional combustion sources should also be continued to ensure long-term maintenance of the NO_x ambient air quality standards.

Efforts have shown that (1) flue gas recirculation is the most effective combustion control technique for NO_x emission from nitrogen fixation and (2) staged combustion is the most effective control method for NO_x emissions from fuel nitrogen conversion. The application of this technology has controlled the NO_x emission from gas and oil fired utility boilers to a level of 150-250 ppm. In short-term testing, combustion modifications have also resulted in NO_x reductions of up to 50 percent in commercial coal-fired utility boilers. In addition, burner and furnace design variables have been shown to cause widely varying NO_x emission levels in all boiler categories. Future R&D efforts will apply the results of this research to the pilot and commercial scale demonstration of combustion control technology for existing and new combustion sources in all size categories.

Synthetic Fuels

Although much of the control required for each sub-task may be developed with funding in Task 3D1, specific problems will be identified here with each technology.

1. High BTU Gasification - Control activities contained in this section should be directed at demonstration of the air, water, and solid waste control technology when applied to the specific conditions associated with the Hi-Gas, CO_2 Acceptor, Synthane and Bi-Gas.

2. Coal Liquification - Control technology requirements for this process center around the development and demonstration of appropriate fine particulate controls and the storage and disposal of slag (ash) and the elemental sulfur produced as a byproduct of SRC processes, H-coal, advanced, and multiple.

3. Low-BTU Gasification - The development of advanced coal gasification processes will require two major R&D efforts: (1) high temperature/high pressure gas cleaning to remove gaseous pollutants as well as fine particulate which can cause both erosion of system components and environmental degradation and (2) isolation and disposal of solid waste streams to control ecological damage. Large quantities of solid wastes are generated from the ash content of the coal and the chemical processing to remove sulfur. The effort should perform a comparative evaluation of the molten salt and dolomite high temperature clean-up systems at the pilot scale leading to selection of the best for demonstration. Pilot and demonstration should be integrated with the basic gasifier systems to which they are to be applied.

4. Synthetic Fuels Pioneer Program - A major concern rests with synthetic Fuels Pioneer Program. The objectives of the program as defined are valid and should be achieved. However, the plans for incorporating environment controls into this program are not evident. While it is not recommended that this vital demonstration program be delayed, it is recommended that work begin immediately on defining the control technology requirements and that the best available controls for air, water and solid waste handling be commercially demonstrated in conjunction with the two selected synthetic fuel processes.

Environmental Control Technology

The objective of this program should be to develop the environmental controls, in conjunction with the various coal combustion processes to insure minimal environment insult in all media resulting from the implementation of these processes. The technology required for these controls are:

-Pre-combustion - Development of physical and chemical coal desulfurization technology will allow the continued use of coal in facilities not suitable for post-combustion conversion. In concert with the development of this technology must be the development of controls for the liquid and solid waste byproducts generated. This technology will permit the essentially complete removal of sulfur as well as particulate and associated trace metal impurities in coal. This may be the best approach to the control of sulfate formation resulting from coal combustion.

-Post-combustion - The cleaning of flue gas emitted after combustion offers a near-term solution for meeting existing SO_x ambient air quality standards. Additional research and development, however, is necessary to adequately demonstrate reliable and efficient performance and to control environmental side effects of this technology. A major problem exists in the collection of fine particulates (2 micron) emitted after combustion. Conventional control equipment is highly inefficient in collection of this most offensive particulate size fraction. Candidate control approaches include condensation scrubbing, electrostatic augmentation and agglomeration.

Safety-Reactors and Fuel Handling

Control technology to assure that radioactivity from fission fuel cycles does not become a significant environmental pollutant must be developed if the currently projected growth rate of the nuclear power industry is to be achieved. The characteristics of radioactivity are such that two types of potential problems must be dealt with. The first stems from those radionuclides such as I-131 with short half-lives which, if released in sufficient magnitude could result in an immediate threat to the environment or public health; this type of release is considered in depth during the sitting, design, and operation of radioactive effluents from nuclear facilities have been made in the past few years for systems related to the uranium fuel cycle. While final demonstration of the adequacy of this new technology remains to be verified utilizing environmental monitoring and surveillance programs on the large LWRs currently beginning operation, it does not appear that major Federal R&D funding for further development of such control technology is required. Development of control technology for advanced systems (e.g., LMFBRs, advanced converters using the thorium - U-233 fuel cycle) cannot be precisely defined at this time, but will be required at a pace dictated by the progress of development of such systems. At this juncture, it appears that radionuclide control technology being developed for the uranium fuel cycle in LWRs will largely suffice for the other fission-fuel cycles.

The second potential problem stems from radionuclides with long half lives (e.g., I-129, the actinides, and, to a lesser extent, Kr-85 and tritium); the longevity of such radionuclides dictates that special consideration be given to assure that accumulation of releases from all nuclear facilities (present and future) will not ultimately result in an environmentally unacceptable situation for a given ecosystem.

The projected increase in the number of LWRs and the onset of large throughputs of spent fuel in the reprocessing plants requires that technology be developed over the next few years for collection and storage of krypton-85 and tritium. Much of the basic research in this area has been completed. A more crucial near-term problem is the lack of available criteria, guides, and environmental standards for the long-term alpha emitters (e.g., actinides) because of the current production of plutonium in LWRs, as well as its potential use as fuel in LWRs and LMFBRs. Lack of guidance in this area is beginning to impact adversely fuel reprocessing and waste handling practices. Unfortunately, there are major uncertainties on the transport of these very toxic materials in the environment. The problem is further complicated in that current technology results in mixtures of the long-lived actinide waste with high-level radioactive waste which would otherwise require isolation for only a few hundred years. Some effort to develop efficient (99.9%) separation of the actinides from other high-level waste components is underway. Success in this area would facilitate subsequent "ultimate" removal of this material if subsequent concepts (e.g., space disposal or transmutation) can be made practicable. With regard to radioactive waste storage and disposal, extensive efforts for handling high-level wastes are already underway, with major emphasis on storage in a retrievable surface storage facility and disposal in a bedded salt geologic formation. Some preliminary information also exists on other geologic formations and the technology of using space is disposal sites. High level waste solidification methods exist in this country and abroad, and solidification methods which would ease subsequent waste storage and disposal problems are currently under development. Current efforts for reducing the volume of solid, low-level alpha wastes are also underway, but storage or disposal of such wastes requires improvement.

Significant information and methods already exist for spent-fuel shipping methods (e.g., casks); however, this technology base will likely have to be improved in view of the major increases in spent-fuel shipping which are anticipated. Methods of adequately and economically decommissioning nuclear facilities at the end of their useful life do not currently exist.

An additional major near-term problem is the long time period required to select and judge the adequacy of sites for major industrial endeavors in general and nuclear facilities in particular. Nuclear facility siting is particularly difficult because of the environmental and public health risks associated with potential accidents, as well as the "normal" environmental impacts resulting from plant effluents (waste heat and radionuclides), use of large quantities of water for cooling, land use for the site and transmission lines, etc. The need for additional efforts in the nuclear facility siting area is particularly important in the near-term since nuclear plants for generating electricity are a current viable alternative to the use of fossil fuels which can be utilized to higher advantage in other endeavors (e.g., transportation). With a projected need for several hundred new sites for nuclear facilities by the year 2000, increasingly severe difficulties will be encountered over the very near term in obtaining sites that will adequately meet all necessary siting requirements. Many potential sites are likely to involve complex siting problems. Continued improvements in siting technology are needed to assure that siting needs can be met.

In addition to restraints related to site selection methods, a major constraint to siting flexibility is a lack of large supplies of cooling water at otherwise acceptable -ower plant sites. This restraint could be significantly eased with the development of air cooling methods, i.e., dry cooling tower technology. Without the option of dry cooling, power plant siting will become extremely difficult in many regions of the Nation by the early 1980's. There is a considerable foundation of existing experience (including foreign experience) upon which to build, but this experience derives principally from applications where lifetime and reliability requirements have been much less demanding and critical than for large scale power plant use. There is some existing foreign experience with a small number of dry cooled power plants up to about 300 MWe in size. In the United States, however, the largest dry cooled power plant operated to date is a 20 MWe fossil unit of the Black Hills Power and Light Company located at Wyodak, Wyoming. A major effort to demonstrate dry cooling tower technology on a large scale has recently been initiated utilizing a joint Government-industry arrangement.

Another area which requires additional R&D to increase nuclear facility siting flexibility involves the development of adequate radiological emergency preparedness capabilities. Current technology in this area has concentrated on preparedness for relatively low-level releases, and utilizing guidance originally developed for nuclear weapons fallout. In the past year, a concerted effort on the part of several Federal agencies (AEC, DCPA, EPA, HUD-FDAA, and HEW) has been undertaken in the area of radiological emergency preparedness which should be of value in the event of incidents or accidents in nuclear facilities. Basic guidance is being developed for state and local officials who would have to act in such emergencies. While extensive emergency monitoring capability appear available for small releases to the environment and for monitoring of foodstudd, adequate rapid emergency monitoring systems which could aid in reaching decisions concerning the need for rapid action (e.g., evacuation do not currently exist).

In general the recommended program included the following:

-Development and demonstration for collection and storage for krypton and tritium effluents from nuclear facilities.

-Development and demonstration of facilities for reducing the volume and subsequent storage/disposal of low-level alpha-contaminated solids.

-Development and demonstration of methods to separate 99.9% of the transuranic from high-level wastes.

-Long-term development of methods of removing actinides (space disposal, transmutation).

-Construction of the Retrievable Surface Storage Facility for high-level waste.

-Development of a high-level waste disposal facility utilizing the bedded salt geologic formation concept.

-Development of improved spent fuel shipping methods.

-Development of adequate economical methods for nuclear facility decommissioning.

Fusion

Controlled thermonuclear technology is in an early stage of development, and its environmental impact is not quantifiable at this time. Identifiable control considerations, however, include the following: Appropriate clean-up techniques will be required for possible coolant systems under consideration (helium, flourine-beryllium, or lithium). Tritium leakage and inventory in fusion systems must be kept at a minimum, and tritium separation methods may be required on a longer time scale to reduce both on-site and off-site radiation exposures. The investigation of improved structural materials to replace long-lived niobium (e.g., vanadium alloys, containing titanium and chromium) may be desirable for reducing long-term radioactive waste storage requirements.

Solar

The use of solar energy appears promising from an environmental standpoint. This is particularly true for the decentralized applications to direct heating and cooling of buildings. In the centralized approaches, however, potential environmental impacts unique to each approach must be evaluated and the resulting control requirements integrated into its development. In the case of Solar Thermal Conversion Systems, large areas of land are required (10-20 square miles per 1,000 MWe). This can create an extensive ecological impact and will probably require carefully developed siting and construction criteria. These impacts will be accentuated by the local change in albedo created by the solar collectors. In the case of Ocean Thermal Conversion, effluent treatment systems must be incorporated for control of biocides and corrosion inhibitors will be required to meet discharge requirements.

Bioconversion to fuels will require liquid and solid waste disposal systems tailored to meet zero discharge requirements. This can be particularly challenging in the case of fermentation plants for animal feedlots wastes. In the case of Photovoltaic Electric Power toxic metal films will be used in large conversion arrays. These must be controlled throughout the manufacturing, fabrication and operational phases to avoid dangerous atmospheric and groundwater emissions.

Geothermal

Geothermal energy sources can create serious environmental impacts through emissions of gaseous pollutants and highly mineralized brines, as well as land subsidence, induced seismic activity, noise, and destructive land use. The cost-effective disposal of such pollutants, preferably by conversion to practically recoverable substances or reinsertion into the lithosphere without interference with the energy extraction process is the primary goal of the environmental control program. In addition, the very low thermal efficiency of geothermal systems (5-20 percent) can create a heat load which may require new disposal mechanisms. Although many potential environmental problems have not yet been quantified because of the early development problems state of all but dry steam systems, it appears that much of the pressing air and water pollution control needs can be addressed by the application of technology developed for fossil fuel pollution control. What is specifically needed in the near term is the adaptation and performance evaluation of these control systems concurrent with the development of each type of geothermal source.

PROGRAM DEVELOPMENT

The translation of the goals and objectives defined in the preceding section into a task level research program has been performed by an Energy R&D Planning Task Force established within EPA. The principle objective of the Task Force, composed of representation from each of the technical disciplines within the Office of Research and Development has been to develop a comprehensive environmental science and control technology R&D agenda which is maximally responsive to the environmental needs of lead energy agency development and policy activities.

In order to consider the energy-related environmental R&D agenda in a problem oriented rather than disciplinary basis the Task Force was organized in a matrix fashion according to five major activity areas in energy development. These were:

- Energy Conservation
- Fossil Fuel Extraction
- Fossil Fuel Combustion and Conversion

- Nuclear Energy Systems
- Advanced Energy Systems (Solar, Geothermal)

The steps followed by the Task Force in achieving this objective may be summarized as follows:

1. Energy R&D and Policy Timeline Definition

The first step in R&D program development by the Task Force was the identification of the energy development and policy decision milestones, and the associated schedules which the environmental R&D program is intended to support. These timelines, defined through communication with the Federal Agency responsible for each technical or policy development, represent a summary picture of Project Independence both in content and schedule. This timeline picture has been published and is available from EPA.

2. Environmental Factors

In order to provide a basis for establishing research priorities as well as scoping the required EPA disciplinary research outputs, the Task Force developed an initial qualitative and where possible, quantitative assessment of the pollutants, by-products, and resource requirements associated with each development or policy timeline.

3. Major Environmental Products Definition

This activity involved an identification by the Task Force of the major environmental products which will be needed to provide an integrated environmental recommendation supporting a specific energy development or policy milestone.

4. Program Output Development

Based on the preceding steps the Task Force identified specific achievable outputs which would be required from each disciplinary Program Element in order to develop the integrated environmental recommendations bearing on energy technology and policy.

5. Program Implementation

The definition of program output requirements completed the formal efforts of the Task Force. These requirements have, in turn been translated into a research plan specifying objectives, priorities, and resources by each of the disciplinary program areas within the EPA Office of Research and Development. Table 1 summarizes the results of this planning in terms of proposed resources associated with each disciplinary program area as a function of activity area in energy development. The implementation and translation of research results into EPA recommendations bearing on the energy decision-making process will involve the following organizational activities:

(a) Each ORD disciplinary program area will manage its energy related environmental research program according to the program output requirements defined by the Energy R&D Task Force, These requirements focus, both in technical content and time, on the key decision milestones in the technology and policy developments associated with achieving energy self-sufficiency.

(b) Integrated assessments of the program area research products will be performed in order to relate the damage potential associated with developmental energy technologies or policies to the costs of alleviating these damages in environmental, economic, and social terms. These efforts will be performed according to schedules which permit the research results to be effectively applied to specific energy R&D or policy decision points. These integrated assessments will be performed by a new analytical group being established in the EPA Washington Environmental Research Center (WERC).

(c) The Energy R&D Planning and Coordination Group within the EPA Office of Research and Development will act as the focal point within ORD for the translation of the integrated assessments either into recommendations bearing on technologies under development by the energy research community or into support for Agency policy. The responsibilities of this office will also include; (1) Maintaining accurate definition of the national energy technology developments together with their associated schedules (2) Developing and coordinating the environmental research strategies associated with these technologies and (3) Insuring that EPA enrgy related environmental R&D programs are conducted in a manner responsive to these strategies and the associated environmental goals.

CONTRIBUTION TO THE ENERGY SYSTEM

Implementation of the environmental research program discribed will make a vital contribution to the national energy system in three critical areas (1) cost (2) usability of domestic energy sources and (3) timelines in implementing energy system initiatives.

With respect to costs, at least $90 billion will be spent by the energy industries in the period 1971-1980 alone, to meet established environmental requirements for the limits set on air and water pollutants. This amount of pollution control expenditure will add about 15 percent to the wholesale delivered national cost of fuel over the same time period. By providing the technical and scientific environmental knowledge to be gained from this research and development program it will be possible to develop and demonstrate environmental controls in conjunction with developing energy technology rather than having to rely on the costly retrofit programs exemplified by the current SO_x control program. It is estimated that the environmental cost to achieve the broad environmental objectives could in this manner be reduced to less than 10 percent of the wholesale delivered national cost of fuel.

The technologic development and implementation of coal-based energy systems for near-term energy self-sufficiency must be sensitive to the effects that residuals from the system will have on health, welfare, and the ecological system. If this sensitivity is incorportated into the development and implementation process these domestic resources can be broadly utilized in harmony with the environment. These effects act as a constraint on the technical requirements for control, the siting of the system and the value of the system as a producer of energy. Further, knowledge of the effects of the system before it is implemented will avoid the enormous costs associated with the need to retrofit controls on an operational system, or to "clean up" the wastes once they have the technical basis for understanding these environmental consequences and balancing the environmental and energy system costs in an equitable manner to the society.

While, in theory, the environmental research program does not add one BTU to the energy balance, in practice the energy supply forecasts made by each technology panel are dependent on demonstrating to a concerned and increasing sophisticated public that environment impacts are understood and controllable to an acceptable level. Recent history has demonstrated that delays can occur due to lack of a sound understanding of energy related environmental questions. Examples of these ddelays which have affected energy supplies have been the Alaska Pipeline and delays in nuclear liscensing. Delays also affected implementation of environment controls as exemplified by litigation of ulitities against installation and operation of SO flue gas clean technology. The environmental research program would also provide the basic understanding necessary to evaluate and measure environmental impacts, determine their effects and to develop and implement timely and minimum cost environmental controls.

Successful implementation of this environmental research program will affect all aspects of the energy program and could be the definitive determinant of optimal energy source use and of the feasibility of specific technology aapproaches. Disruption of the energy program can be prevented by anticipating potential problems related to each technology and by determining as rapidly as possible the effects on health, ecosystems and society. Perhaps the largest barrier to be faced is the need to convince energy-related technologists and planners that this seemingly distractive commitment must be made at the outset to prevent very major disruptions in energy production.

SESSION V:

ASSESSMENT OF FULL UTILIZATION OF WATER POLLUTION CONTROL TECHNOLOGY

Moderator:

G. Strasser

Strasser Associates, Inc.

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ENVIRONMENTAL QUALITY IMPROVEMENT THROUGH SYSTEMATIC IMPLEMENTATION OF POLLUTION CONTROLS

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ABSTRACT

The Clean Air Act of 1970 and the comprehensive Federal Water Pollution Control Act Amendments of 1972 require achievement of national ambient air quality standards on the one hand and specific water effluent standards for individual facilities on the other. In the process of improving the air and water quality individually, these limitations on pollutant discharge often have important secondary impacts. The control technologies which are aimed at achieving the discharge limits often generate new waste streams which in turn require controls. Without a systematic assessment of these impacts, there is substantial risk that pollution control strategies for controlling pollution in one medium will exacerbate problems in another medium. This paper describes and discusses the elements necessary for this assessment. The assessment methodology consists essentially of developing an index for each control strategy and comparing it with a corresponding index for the uncontrolled case. The index is a function of three elements: (1) the rate of production of pollutants; (2) the behavior of those pollutants in the environment; (3) the relative importance of each pollutant. Application of these three elements yields an expression of strategy effectiveness in terms of the net effect of a particular strategy upon the environment. A case study of an integrated iron and steel production facility was used to verify the methodology. In addition to the strategy effectiveness index, the costs associated with each strategy in terms of energy consumption, capital costs, and operating costs, were also developed.

INTRODUCTION

In the United States, the maintenance of a high physical quality environment for all is being addressed in a piecemeal fashion. Instead of viewing the environment as a complex system having many interrelationships, it is viewed simply as having three independent media; land, water, and air. Further, it is assumed that by maintaining quality in each of these media, a high quality can be maintained for the entire environment.

Following this philosophy of environmental quality management, quality standards are established for each medium. These standards are used to regulate the pollutants discharged into the media, and thus maintain the desired environmental quality. Examples of standards that are currently being used to regulate pollutant discharges are the Clean Air Act of 1970 and the Federal Water Pollution Control Act Amendments of 1972.

Unfortunately, this philosophy fails to consider the interaction or cross media impact that exists between media during the implementation of standards. Such interaction may cause the implementation of a standard on a single medium to improve that medium but to decrease the net quality of the three media.

Effluent standards are a means of maintaining a high quality environment. These standards are implemented through the use of controls on the waste discharges into the three media. Cross media impacts are created from the new waste streams generated by the controls. Without systematic assessment of all waste streams, those generated by processes and those generated by processes and those generated by controls, there is risk that the pollution controls will not provide the desired high quality environment.

This paper describes and discusses the elements necessary for a systematic assessment of pollution control strategies.* It compares the relative effects of trading impacts in one medium for impacts in another medium. The methodology is used to develop a Strategy Effectiveness Index for the selection of the controls necessary to maintain a high quality environment.

METHODOLOGY

Traditionally, pollution control strategies have been selected almost entirely on their efficiency in reducing, modifying, or eliminating pollution in one selected medium: air, water, or land. As controls become more stringent, however, experience indicates that cross-media impacts associated with control strategies often can be serious. A systematic analytical approach is required to examine strategies within a total environment framework. This paper describes a methodology that can be used to differentiate between alternative pollution control strategies based on their control effectiveness in all three media.

Industrial processes generate waste streams which are either discharged directly to the environment or modified by a control process, and then discharged to the environment. The control process in turn generates its own waste stream which is also discharged to the environment. Both of these waste streams are normally defined by various physical/chemical pollutants. In general, each of these pollutants affects the environment to a different degree, and the significance of the effect on the total environment is different.

To use this pollutant information for comparing control strategies or for selecting the "best" strategy, it is desirable to express the information in a single index. This index requires that trade-offs between pollutants be explicitly stated and provide a simple means for differentiating between strategies. The Strategy Effectiveness Index (SEI) is designed to satisfy these needs.

The SEI is obtained by subtracting the impact resulting from a particular control strategy from the impact resulting from no control. This impact is defined by an Environmental Degradation Index (EDI). Therefore, the effectiveness of any strategy can be expressed in terms of SEI by using the relationship:

$$SEI_s = EDI_{(uncontrolled)} - EDI_s$$

The EDI is a function of three elements:

(1) The rate of production of pollutants
(2) The environmental damages created by each pollutant
(3) The relative importance of each pollutant.

Rate of Production of Pollutants

Waste streams from industrial processes and control strategies can be defined by their physical/chemical parameters. Parameters for air, such as sulfur oxides, lead, and particulates; for water, such as alkalinity, sulfates, chlorides, and dissolved solids; and for land, such as organic refuse and glass, might be used to describe the waste streams.

The pollutants included in this element are generated in the production and the control process. They are measured by performing a materials balance on both of these processes. To aid in developing a comprehensive list of pollutants, a three-step structure is used:

STEP 1. Identify expected pollutants for a specific industry by using the industrial classification developed by EPA.

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*Reiquam, H., Dee, N., and Choi, P., "Development of a Cross-Media Evaluation Methodology", Final Report to Council on Environmental Quality and Environmental Protection Agency, by Battelle-Columbus Laboratories, January, 1974.

STEP 2. Identify the pollutants associated with each defined control strategy.

STEP 3. Categorize each pollutant in a two-level hierarchy consisting of the medium at the first level and the pollutant at the second.

Environmental Damage Created by Pollutants

The environmental damage associated with each control strategy is a function of the waste generated and its behavior in the environment. The potential damage of waste production is first measured by using damage functions. This potential is then adjusted by the pollutants' behavior in the environment.

Development of Damage Functions

The potential impact resulting from the discharge of a pollutant into a medium is measured by a "damage function". This function transforms the total production of a pollutant discharged, industrial and control, into a corresponding index of potential environmental damage. The index is a number between 0 and 1, where 0 denotes no potential environmental damage and 1 extremely high potential environmental damage.

The functional form relating the total production of a pollutant discharged to potential environmental damage can be described as a general S-shaped curve as shown in Figure 1.

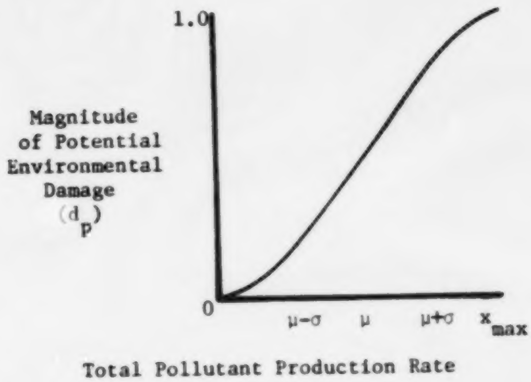

Figure 1. Form of damage function.

The exact mathematical relationship of the damage function is described by the cumulative density function of a normally distributed random variable, where d_p is the index of potential environmental damage for discharging pollutant p, x is a possible rate of pollutant discharge, μ and σ are mean and standard deviation respectively, and Z is the actual amount of pollutant discharged. The measurement of a pollutant goes from 0 to some maximum value x_{max}.

$$d_p = \frac{1}{\sigma \sqrt{2\pi}} \int_0^Z e^{-1/2\left(\frac{x - \mu}{\sigma}\right)^2} dx .$$

Behavior of Waste in the Environment

Various pollutants have different environmental impacts depending upon their behavior after they are discharged. Indeed, some wastes are not discharged in the usual sense of the word, in that they remain under the control of man. It is clear that their ultimate potential for damage probably is much less than that associated with a pollutant which, once discharged, can eventually pervade the entire environment.

The damage functions described above are based solely upon the maximum production of each pollutant within each industrial plant class. Modifiers of each damage function then are required in order to take into account these behavioral differences. These modifiers are based upon the natural dispersion of the pollutants, their persistence in the environment, and their capability of being transferred by deposition, precipitation, or leaching, from one medium to another. In view of the fact that the interest here is in the impact of one pollutant as compared with another, the relative values of these modifiers are most important; modifiers for each pollutant damage function must be obtained in a consistent and straightforward way.

The equation used in calculating the modifier is

$$C = x + t + e$$

where x, t, and e refer to the dispersal range, persistance, and media exchange capability, respectively.

Values used in the computation of C are given in Table 1. Once the value for C has been obtained, the modifier, M, is determined by multiplying C by 0.1. This transformation allows the damage to remain between 0 and 1.

TABLE 1. EQUATION VALUES

	1	2	3
Dispersal Range (x)	local	regional	global
Time (t)	days	weeks	years
Exchange (e)	no transfer	transfer	

Procedure for Calculating Environmental Damage

As indicated earlier, the magnitude of environmental damage associated with each control strategy under consideration is a function of the production of waste materials produced and the behavior of those wastes in the environment. That magnitude is obtained in three steps. First, enter the appropriate damage function with the mass of pollutant p produced by the strategy; second, read d_p; third, multiply d_p by the appropriate damage function modifier M. The damage due to production of each pollutant thus depends upon specific consideration of an industry, and upon general consideration of the behavior of that pollutant once released to the environment.

Relative Importance of Pollutants

Besides measuring the magnitude of the damage caused by a pollutant discharge, it is also necessary to measure the significance of the damage to the environment. Some pollutants affect many elements of the natural and man-made environment, while others affect only a few. In addition, some pollutants cause acute environmental damages while others cause only chronic damages. The differentiation between pollutant discharges and their resulting damage is obtained by relatively weighting all pollutants. This weighting explicitly indicates the significance of an environmental damage caused by each pollutant.

In assigning relative weights, consideration must be given to the different environmental conditions that occur throughout the United States. Regional differences occur because of the different assimulative capacities of the environment as well as the different perceived importance attributed to environmental damages by the population. It is therefore desirable to obtain weights for the three media and associated pollutants for each of the many regions throughout the United States.

There are many procedures available for assigning relative weights. Two of the most common are the use of judgment of knowledgeable individuals, experts, and the use of estimates of "social" costs or damages. Both methods are discussed in this paper.

Types of Weights

The three media used for disposal of wastes are constant for all industrial categories and pollution control strategies, but vary in importance throughout the United States depending on physical, economic, and social characteristics of the area. The pollutants used to describe each medium, on the other hand, only vary among industry categories and control strategies. For these reasons a hierarchical arrangement of weights was developed consisting of two levels:

Level 1: Media weights
Level 2: Pollutant weights.

Expert Judgment

Delphi Technique. Determination of weights for the three media and associated pollutants based on expert judgment is an important and difficult task. Historically weights were implicitly assigned using "intuition". As the decisions became more complex, it became necessary to develop a technique for using expert judgment to determine weights explicitly. It was necessary for the technique to be consistent, systematic, and explicit, and to use inputs from several decision makers.

The technique used in this study to obtain expert judgment is basically a structured procedure for gaining consensus.

In this technique individuals focus on and debate issues anonymously, thus allowing systematic determination of consensus or dissensus. The technique helps illuminate basic differences in values and beliefs, and clarifies and removes communication difficulties. The technique is conducted through several rounds, with the results of each round being given to the participants prior to the next round. The results of each round inform the participants on the aggregate attitude of the participants, and allow them to modify or accept the aggregate results.

National Weights. This Delphi procedure was used to obtain both levels of relative weights; media and pollutant. The first level, media, weights were obtained by using opinions of individuals from the Environmental Protection Agency located in regional offices throughout the United States. The second level, pollutant, weights were obtained by using opinions of experts at Battelle-Columbus Laboratories.

To obtain the media weights, members of the Battelle research team visited all ten regional offices of EPA. With the cooperation of the director of each office, appropriate staff were selected to participate in the weighting exercise.

Each staff member first participated in the delineation of an inclusive set of subregions. Then they were individually asked to express for each subregion their opinion of the "level of concern about each medium as a depository of wastes". Their stated opinion was not EPA's position on waste disposal, but a composite opinion of the population, industry, and government in the subregion. Basically, the EPA personnel were sensors of the subregion's position on waste disposal.

The information from these weightings were used as input into a model that estimates the media weights given only physical, economic, and social data of the subregion. This model eliminates the necessity of performing a media weighting every time a different pollution control strategy is evaluated. It also provides the sensitivity and flexibility of working at various spatial levels.

The model is given below

$$MW_{ik} = f(P_{jk}, E_{jk}, S_{jk})$$

where

i = medium index

j = characteristic index

k = subregion

MW_{ik} = medium weight for subregion k, $i = 1, 3$

P_{jk} = physical characteristics for subregion k, $j = 1, M$

E_{jk} = economic characteristics for subregion k, $j = 1, P$

S_{jk} = social characteristics for subregion k, $j = 1, N$

M = total number of physical characteristics

P = total number of economic characteristics

N = total number of social characteristics.

The model was estimated using a statistical technique called Automatic Interaction Detector (AID). The program collapses measurements or estimates of several characteristics into a single medium weight. The AID program is a multivariate technique for determining what characteristics and levels of these characteristics are statistically the most reliable predictors of the weight.

After appropriate coefficients were determined for this model a national average of all 48 subregions was obtained. These relative estimates which appear in Table 2 are based on a total of 1000 points.

TABLE 2. ESTIMATES OF MEDIA WEIGHTS: EXPERT JUDGMENT

Media	Weight
Air	290
Water	390
Land	320
Total	1000

Economic Indicators

All costs of production and consumption are not accounted for under our present market institutions. While the price of a product roughly corresponds to the cost of the various inputs, the cost or damage of side effects is seldom included. Monetary approximation of these "social costs" of production and consumption provides a method of weighting the importance or significance of the respective damages to the environment defined by the water, air, and land media.

Water Medium. The social costs of discharging waste into the water medium are given in Table 3. They are identified by their impact areas which are not mutually exclusive. Unfortunately, data were not available to further delineate these costs by the specific pollutant types.

TABLE 3. NATIONAL SOCIAL COSTS: WATER MEDIUM, 1970 ($ billion)

Effects (Loss Category)	Total Social Costs	Source
Industrial	.5	1
Municipal/Domestic	1.75	2
Recreation	2.4	1
Ecology (Change in Property Value)	.8	3
Aesthetic	(60-100% of Total)	4
Total (Using 80% Aesthetic Damages)	9.8	

SOURCES:

1. Tihansky, Dennis P., *Economic Benefits of Water Pollution Control in the United States*, Environmental Protection Agency, Washington, D. C., 1973.
2. Tihansky, Dennis P., *Economic Damages to Household Items from Water Supply Use in the United States*, Environmental Protection Agency, June, 1973.
3. David Dornbush and Company, Inc., *Benefit of Water Pollution Control on Property Values*, Prepared for Environmental Protection Agency, 1973.
4. Ralph Stone and Company, Inc., *Socio Economic Study of Mutual Use of Water Supply Reservoirs*, Prepared for Office of Water Resources Research, 1971.

Air Medium. The social costs of discharging waste into the air medium are given in Table 4. They are identified by their impact area as well as by the specific pollutants. The 1968 costs given in the source study have been inflated to 1970 values using the consumer price index.

TABLE 4. NATIONAL COSTS OF AIR POLLUTION DAMAGE BY POLLUTANTS, 1970 $ billion)*

Effects (Loss Category)	SOx	Particulate	Oxidant	NOx	Total
Residential Property	3.14	2.68	--	--	5.82
Materials	2.47	0.77	1.26	0.82	5.32
Health	3.66	3.12	--	--	6.78
Vegetation	0.01	0.01	0.07	0.04	0.13
Total	9.28	6.58	1.33	0.86	18.05

*Source--Barrett, Larry B., and Waddell, Thomas E., *Cost of Air Pollution Damage: A Status Report*, Environmental Protection Agency, National Environmental Research Center, Research Triangle Park, North Carolina, 1973.

Land Medium. The social costs of disposing waste on or in the land is the least studied of the three media. Effects that can be measured in terms of marketable goods and services are usually the result of airborne or waterborne pollutants, and are determined elsewhere. Damages because of aesthetic degradation are location specific, while destruction of land form or wildlife habitat from waste disposal has not been measured adequately. As a consequence, only the cost of waste disposal is available.

The disposal cost is estimated to be $5.7 billion dollars. It is based on annual operating, maintenance, and depreciation costs. The costs include the collection and disposal of residential, commercial, institutional, and industrial waste. This cost figure is a significant underestimation of the true social cost, and hence this should be recognized when a comparison of other media is made. The estimate is taken from the Council on Environmental Quality Report of 1971.*

Comparison of Alternative Weighting Procedures

The two methods of determining the relative importance of various pollutants, expert judgment and economic indicators, both have substantial merit. The common scale underlying economic indicators has obvious appeal; it has clear meaning to everyone. The essentially qualitative relative importance obtained from expert judgment, on the other hand, is easily rejected by people without technical knowledge of the specific problem areas in question. Yet, precisely because those judgments are elicited from experts, they will in general reflect the importance of impacts for which no cost data are available.

Three criteria were used to select between the two weighting procedures; consistency, comprehensiveness, and flexibility. The expert judgment procedure was judged more consistent than the economic procedure. All expert judgments were obtained under similar control conditions while the economic data had wide variation of sources and assumptions. The same procedure was also judged to be more comprehensive. Weights were available by region and by pollutant. This was not true for the economic procedure. Finally, expert judgment was also considered more flexible. It was felt that expert judgment was easily adaptable to different industry types and to different data availability.

Therefore, for the purpose of comparing the effectiveness of competing pollution control strategies, it is concluded that the relative weights to be assigned individual pollutants should be derived from expert judgment rather than from presently available economic indicators.

Although expert opinion is suggested the procedure that should be followed for obtaining weights, a comparison of the national results of the expert opinion and economic analysis is given below. The economic data were normalized and expressed in the same format as the expert opinion, 1000 points.

	Expert Opinion	Social Costs
Air	290	540
Water	390	290
Land	320	170
Total	1000	1000

It is felt that the relatively high social cost weight given the air medium is a function of both the significant research directed at determining the social costs of air pollution and the failure to account for the large percent of the United States that is not urban. If the expert opinion were grouped by an urban, nonurban dicotomy, the air medium would have a higher value for urban than nonurban. The primary reason for the low social cost value for land is the lack of data upon which to measure the social costs.

Calculation of a Strategy Effectiveness Index

The specific procedure that should be followed to compute a SEI for a control consists of seven steps.

STEP 1. Identify Pollutants. Waste streams from the industrial processes and control strategies are defined by physical/chemical pollutants. These pollutants and their production are identified and then tabulated according to their controlled and uncontrolled states.

STEP 2. Determine Potential Environmental Damage. For each of the pollutants identified in Step 1, determine the potential damage created by the discharge of the wastes. The damage (d_p) is obtained from the damage function by entering the function with the total mass of pollutant p, and then reading the value, d_p.

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*Council on Environmental Quality, Environmental Quality--The Second Annual Report, Government Printing Office, Washington, D. C., 1971.

STEP 3. Determine Damage Modifiers. The damage computed in Step 2 must be adjusted to account for the behavior of the pollutant in the environment.

STEP 4. Determine Importance of Media. The significance of the damage created by the discharge of pollutants into the environment is expressed by a relative weighting of the media. If national weights for the media are used, they appear in Table 2. If, on the other hand, regional weights are desired, the model developed using an AID analysis is applied.

STEP 5. Determine Importance of Pollutants. After the media weights have been assigned, they can be proportioned to the individual pollutants. A pollutant weight is expressed as percent of the medium weight under which it is grouped.

STEP 6. Compute Environmental Degradation Index. The Environmental Degradation Index (EDI) can now be calculated for both the controlled and the uncontrolled state.

$$EDI_s = \sum_p (M_p \times d_{p,s} \times w_p)$$

where

s = strategy index

p = pollutant index

$d_{p,s}$ = damage for pollutant p when strategy s is applied ($0 \leq d_{p,s} \leq 1$)

w_p = national weight of pollutant p

M_p = pollutant damage function modifier.

STEP 7. Compute the Strategy Effectiveness Index. After computing the EDI for both the controlled and uncontrolled states, it is possible to compute the Strategy Effectiveness Index (SEI).

$$SEI_s = EDI_{(uncontrolled)} - EDI_s.$$

CASE STUDY

To assure that the methodology is usable, it has been applied on the Integrated Iron and Steel Industry. The steel industry was selected as one which has undergone substantial cleanup. Many of the techniques employed to abate air pollution have led to increased production of water pollutants which in turn have been abated.

The seven steps described earlier are used in this example. In Table 5 the pollutants are identified along with their rate of production. Also in Step 1, the control systems are identified and are listed in Table 6.

TABLE 5. STEP 1. IDENTIFY POLLUTANTS (uncontrolled)

Air	
Oxides of Nitrogen	15 lb/hr
Sulfur Dioxide	1,932 lb/hr
Carbon Monoxide	507,830 lb/hr
Particulates	39,420 lb/hr
Total Organic Material	1,599 lb/hr
Ammonia Products	65 lb/hr
Chlorides	542 lb/hr
Calcium Fluoride	71 lb/hr
Phenols	6 lb/hr
Cyanides	90 lb/hr
Water	
Suspended Solids	6,880 lb/hr
Ammonia Nitrogen	226 lb/hr
Phenols	87 lb/hr
Cyanides	1.2 lb/hr
Cyanates	35 lb/hr
Chlorides	11,880 lb/hr
Oil	1,594 lb/hr
Hydrochloric Acid	138 lb/hr
Land	
Dry Dust	0 lb/hr
Sludge	0 lb/hr

TABLE 5 (Continued)

Byproducts	
Metallic Dust	0 lb/hr
Metallic Sludge	0 lb/hr
Oil	0 lb/hr
Acid	0 lb/hr
Iron Oxide	0 lb/hr

The magnitude of the environmental damage is given in Table 7 and the damage function modifier and the pollutant weights, Steps 3-5, are given in Table 8. The final strategy effectiveness index for the two controls is given in Table 9, along with energy demands and cost considerations.

Application of air pollution control systems alone leads to a very large increase in the production of suspended solids and cyanides as water pollutants, and of dry dust as solid waste. Thus, although there are markedly smaller emissions of air pollutants, the cross-media impact is substantial and the net gain, or Strategy Effectiveness, is not great. Application of water pollution systems alone does not have a comparable

TABLE 8. STEPS 3-5. DAMAGE FUNCTION MODIFIER AND POLLUTANT WEIGHTS

Pollutant, p	Weight W_p	Modifier M_p
Oxides of nitrogen	22	0.5
Sulfur dioxide	43	0.7
Carbon monoxide	26	0.3
Particulates	56	0.8
Total organics (to air)	30	0.5
Ammonia products	47	0.5
Chlorides (to air)	47	0.4
Calcium fluoride	43	0.4
Phenols (to air)	56	0.4
Cyanides (to air)	60	0.4
Suspended solids	71	0.6
Ammonia nitrogen	52	0.6
Phenols (to water)	84	0.5
Cyanides (to water)	75	0.5
Cyanates	56	0.5
Chlorides (to water)	33	0.6
Oil	71	0.5
Hydrochloric acid	28	0.4
Dry dust	42	0.5
Sludge	58	0.6

TABLE 6. STEP 1. IDENTIFY POLLUTANT CONTROLS

Air Control Only

Plants	Control System	Capital Cost, $	Annual Operating Cost, $
Coke Oven	High Energy Wet Scrubber	10,500,000	2,262,000
Sinter	Electrostatic Precipitator	1,500,000	501,500
Blast Furnaces	High Energy Wet Scrubber	5,100,000	413,000
Basic Oxygen Furnaces	Electrostatic Precipitator	10,000,000	1,059,000
TOTAL		27,100,000	4,235,500

Water Control Only

Plants	Control System	Capital Cost, $	Annual Operating Cost, $
Coke Oven	Biological System	2,150,000	1,181,000
Hot Rolling Mill	Primary Clarifier and Filter Systems	18,140,000	1,576,000
Acid Pickling	Regeneration System	1,278,000	115,000
TOTAL		21,568,000	2,872,000

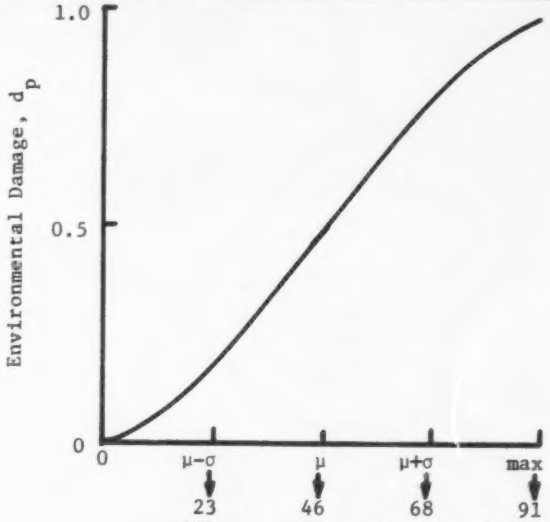
great. Application of water pollution systems alone does not have a comparable deleterious effect on air, so although it increases the production of solid wastes it results in a substantial net gain.

Combined air and water pollution control results in a higher Strategy Effectiveness than a simple sum of the two more basic strategies because it yields nearly all of the individual gains of both, without producing the negative impacts on water which stem from air pollution controls alone.

CONCLUSIONS

A methodology has been developed in this paper for assessing the effectiveness of control strategies applied to a single medium in terms of their impact on all environmental media. It appears that the approach developed is sufficiently general to allow for a more systematic assessment of the cross-media impacts of proposed pollution control standards. It should hopefully prove useful as one of the tools for making decisions as to which control techniques are most appropriate for meeting standards in a way to provide a net improvement in environmental quality.

TABLE 7. STEP 2. DETERMINE MAGNITUDE OF ENVIRONMENTAL DAMAGE



	μ−σ	μ	μ+σ	max
NO_x, lb/hr	23	46	68	91
SO_2, lb/hr	493	986	1,479	1,972
CO, lb/hr	126,958	253,915	380,872	507,830
Particulates, lb/hr	9,855	19,710	29,566	39,421
Total organics, lb/hr	400	800	1,200	1,599
Ammonia products, lb/hr	16	32	49	65
Chlorides, lb/hr	136	272	406	542
Calcium Fluoride, lb/hr	18	36	53	71
Phenols, lb/hr	2	3	4	6
Cyanides, lb/hr	22	45	68	90
Suspended Solids, lb/hr	5,098	10,195	15,292	20,390
Ammonia nitrogen, lb/hr	56	113	170	226
Phenols, lb/hr	23	46	70	93
Cyanides, lb/hr	23	46	68	91
Cyanates, lb/hr	9	18	26	35
Chlorides, lb/hr	3,085	6,170	9,255	12,340
Oil, lb/hr	398	797	1,196	1,594
Hydrochloric acid	34	69	104	138
Dry dust, lb/hr	3,918	7,835	11,752	15,670
Sludge, lb/hr	434	868	1,303	1,737

TABLE 9. STEPS 6-7. STRATEGY EFFECTIVENESS INDEX

Strategy	Costs			Strategy Effectiveness Index
	Energy, kw	Capital, $	Operating, $/year	
3×10^6 tons/year Integrated Steel Mill				
Air Pollution Control only	10,134	27.1×10^6	4.24×10^6	55
Water Pollution Control only	914	21.6×10^6	2.87×10^6	145
Air and Water Control	10,959	61.7×10^6	7.46×10^6	243

HEALTH ASSESSMENT OF FULL UTILIZATION OF WATER POLLUTION CONTROL TECHNOLOGY

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ABSTRACT

In the development and utilization of technology to protect the public health and the environment from water pollution, we must carry out research to ensure that the new technologies themselves do not create unacceptable public health or ecological problems. In order to set reasonable goals for water pollution control technology, additional research must be carried out to expand the water quality criteria relating to health. To protect the public health, additional criteria are necessary for drinking water, fish and shellfish, irrigation water, and water drunk by livestock. Those areas addressed by the EPA research program are described. The advantages and limitations of epidemiology, animal studies, and clinical research in providing these criteria are discussed. Health aspects of EPA's wastewater reuse policy are summarized. It is recommended that water criteria indicate the relationships between pollutant levels in water and health risk, so that officials may choose standards which are appropriate to local social and economic conditions. The wise expenditure of billions of dollars on water pollution control technology requires a substantially increased effort to quantitate the benefits and risks of control.

The purpose of water pollution control technology is to prevent damage to the health of man and other living creatures, and to materials. The stringency of control which is feasible is a function of the risk of adverse effects at various levels of control, the availability and cost of control technology, and the period of time for applying the technology. It is interesting to compare progress in water pollution control with progress in air pollution control. Water pollution control has gradually gained momentum over many years. The activity now appears to be rapidly accellerating. To the degree that high costs are necessary to meet standards within a short period of time, a reexamination of the data upon which standards are based, in an attempt to lower costs without concomitant embarrassing health effects, will be made. For example, automotive emission standards were specified in the Clean Air Act amendments in December 1970. The high cost of meeting these emission standards in the short time available led to the development of control technology, specifically catalytic converters, which would substantially reduce the pollutants specified in the Clean Air Act, but at high costs and with control technology which promised to substitute for the harmful pollutants named in the Clean Air Act potentially harmful amounts of pollutants such as sulfuric acid mists. Because of the speed with which the law required emission standards to be met, the potentially adverse effects of the proposed control technology were found out just in time to prevent both government and industry from permanently locking into a technology which had not been completely assessed for its own health effects.

When the Energy Crisis became increasingly apparent, the Senate Committee on Public Works called upon the National Academy of Sciences to examine the health basis for the Air Quality Standards. It is interesting that they did not request any evaluation of the standards that were based on damage to wildlife and materials. In general, the air standards to protect wildlife and materials were more stringent than those to protect health, but in a crunch, it was concluded that wildlife and materials must suffer before man, and many considered retrenchment to lower standards at the second line of defense -- that essential to protect human health. Some experts, such as Dr. Bertram Dinman, told the National Academy of Sciences that society might reduce the costs of air pollution control by considering paying for the relocation of those individuals who are especially susceptible to adverse health effects from air pollution into areas which are less polluted.

Let us compare this situation with problems in water pollution control. It may well be that analagous problems are just a little way down the pipe. Perhaps we can use our hindsight from air pollution control to avoid making the same mistakes in the water area. The Federal Water Pollution Control Act Amendments of 1972 came just about two years after the Clean Air Act Amendments.

Under the water amendments, it is clear that Congress was eager to get water pollution control activities underway regardless of whether or not scientists could agree on what levels were necessary to protect the health of man and beast. Nevertheless, Congress recognized that certain toxic pollutants required standards for effluents into water regardless of the state of advancement of control technology. EPA is now in the midst of trying to set such toxic pollutant effluent standards. In this task, the water quality criteria recently revised by the National Academy of Sciences and by EPA provide the best source of data. In numerous instances, the levels at which the chemicals have adverse effects on fish are enumerated. But what if society decides that the cost is too great to bear to protect fish in certain areas for a while. Perhaps society would then decide as was discussed in the case of air pollution above, to set interim standards at levels which might not be fully protective of the fish, but would safeguard man from adverse effects from eating fish produced in certain areas. Or perhaps our concern would be to protect man from chemicals which would necessarily enter water supplies for a time and for which no drinking water treatment technology was available. Or perhaps society would choose to control to the point of acceptable risk for swimming, but not to be fully protective of fish or other organisms in the water. Well, I think we would be in trouble then. Such human health criteria are sparse or absent for all three alternatives.

And what about the adverse effects of fully utilizing modern water pollution control technology? Have we studied illnesses in individuals living downwind from activated sludge sewage treatment plants? Have we studied the impact on air quality of incinerating sludges containing chemicals such as lead from street surface runoff? Have we determined the degree to which vegetation takes chemicals from sludges disposed on land and concentrates them to levels which might be adverse to man or livestock or both? Have we followed populations of swimmers in various types of water with controls to determine the health impact of various recreational water qualities? Have we set food standards or goals for chemicals in fish, shellfish, plants, or livestock and thus derived water quality goals to protect man? Have we studied the environmental degradation of the toxic chemicals which industries and municipalities put into the water, and the ability of existing drinking water treatment technology to remove such chemicals from the raw water? Hardly at all. Well, what will happen? Will the decision makers rely on the existing data describing toxic effects on fish production, or will these decision makers, including the courts, hold that there is insufficient evidence to require controls? Probably a mixture of both from time to time, depending upon the individuals involved in the decision. In the absence of data, decision makers must fall back on their personal philosophies. Some will prefer to err on the side of safety, others on the side of preventing possibly unnecessary costs.

What can we do? Well, engineers and administrators can learn to accept the need for evaluating the potential adverse health and environmental impacts of new technologies. What disciplines and capabilities are available to us should we choose to fill these gaps? I think it is clear that we must first decide what is a desirable level of chemicals or microorganisms in the media which come into contact with man. With respect to water pollution, these media include our drinking water, the water we swim in, fish and shellfish grown in water, plants irrigated by water, and livestock, which drink water. In every instance, except perhaps for swimming, setting the maximum desirable level requires knowledge of human consumption patterns. We must determine how much water people drink and how much of various food stuffs people eat. Since these patterns are highly variable, administrators at this step must consider what percentage of the population they are going to protect. Does the person on the tuna Weight Watcher's diet require the same degree of protection as the person who has precisely average food consumption patterns? In order to set standards for chemicals in water or foods grown with or in water, we utilize market surveys in conjunction with data from epidemiology, animal exposure studies, and intentional and accidental human exposure studies.

Epidemiology permits us to study populations in real life settings. Since individuals are already exposed to some chemicals and microorganisms at levels of concern, we have a social responsibility to do epidemiology. Epidemiology also permits us to study the effects of chronic exposure of humans, to look at variability in the pollutant burden among many individuals, and to assess any health benefits before and after controls are instituted. With epidemiology, we can look in humans for effects that we suspect might be there based on animal studies, we can study the interaction of disease with pollution exposure, and we can study outbreaks. Then why is so little epidemiology done? It's expensive, there is an incredible shortage of epidemiologists, and among present ones, there's often a lack of interest. If you must publish or perish, you may shun work which requires intensive efforts but produces few publications.

A cheaper way of getting information on desirable levels of chemicals in food and water is through controlled animal exposure studies. They permit controlled dose-response studies at all desirable points on the response curve, sacrifice of the animal before his natural death in order to look for tumors or fetal deformities, as well as the option for life-time chronic studies under controlled exposure. They also permit controlled studies of several pollutants simultaneously. But most important, with animal studies, we can assess a problem before human population exposures ever occur. Unfortunately, we still have considerable difficulty in extrapolation of animal toxicity results to man.

A third technique available for determining desirable levels of environmental agents in food and water from the perspective of human health is clinical research. Volunteers may be exposed to some chemicals, where adverse effects are not anticipated, and human absorption, metabolism, and excretion of the pollutants studied. In addition, clinical investigations may secure valuable information by studying those accidentally exposed. Clinical research enables us to study the effects of experimental exposure on the course of disease, to do some dose-response studies, to intensively study a few naturally exposed subjects and perhaps thereby identify new response indicators, and to verify results of toxicologic and epidemiologic studies, thus strengthening an existing data base. Well why don't we do more clinical research? Well, these studies are expensive too, and it is apparent that investigators must be exceedingly thoughtful and discreet. Furthermore, absolutely necessary checks and balances to protect the rights of subjects are time consuming and sometimes abrasive to the investigator.

In the case of drinking water, once we have determined a desirable level of a chemical or other pollutant in water, we can set about utilizing or developing the technology to achieve this goal. But in the case of foods grown in or with water, the matter is much more complicated. For example, in order to set an effluent standard for a chemical into water, we must consider the degree to which the effluent chemical will be diluted, its environmental degradability or persistence, its direct concentration from the water into the organism which man consumes, and its concentration through a chain of organisms ultimately reaching man. Unfortunately, agencies directly concerned with food regulations have not acquired immense expertise in the latter areas, and agencies concerned with environmental water in our rivers and streams have not developed enough expertise at determining desirable levels of chemicals in food and then extrapolating from such goals in order to pollution, these media include our drinking water, the water we swim in, fish and shellfish grown in water, plants irrigated by water, and livestock, which drink water. In every instance, except perhaps for swimming, setting the maximum desirable level requires knowledge of human consumption patterns. We must determine how much water people drink and how much of various food stuffs people eat. Since these patterns are highly variable, administrators at this step must consider what percentage of the population they are going to protect. Does the person on the tuna Weight Watcher's diet require the same degree of protection as the person who has precisely average food consumption patterns? In order to set standards for chemicals in water or foods grown with or in water, we utilize market surveys in conjunction with data from epidemiology, animal exposure studies, and intentional and accidental human exposure studies.

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What is the Environmental Protection Agency doing to increase the data base for assessing the health benefits of water pollution control technology, and the health risks of such technology, if any? The first table illustrates EPA's ongoing program in water health effects research. After each program the amount being spent in thousands of dollars and the number of man-years of effort on each program are enumerated.

When considering that none of these efforts are funded at more than half a million dollars per year, it is interesting to recall that our society is spending several billions of dollars per year to apply technology to the solution of problems elucidated in major part by this very modest program. Are the American people getting their moneysworth from water pollution control technology? This is the kind of work that enables us to answer that question. Table II on the following page shows a small addition to the preceeding list describing a new program to assess possible adverse health effects from waste water and sludge treatment and disposal.

TABLE I. EPA WATER HEALTH EFFECTS RESEARCH (FY 74)

I.	Occurrence & effects of organic contaminants in drinking water -- isolation, identification, assessment of the acute toxicity of organic chemicals in tap water	$398K/9MY
II.	Occurrence & effects of inorganic contaminants in drinking water -- identify inorganic contaminants & determine significance of occurrence -- toxicological studies for lead, cadmium, barium & asbestos -- epidemiologic surveys (silicate, nitrate) -- carcinogenic/mutagenic potential of raw versus finished water	$350K/13MY
III.	Biological contaminants of water supplies -- review & determine the cause of water borne disease outbreaks -- survey of water supplies for virus, bacteria, and higher parasitic forms	$300K/13MY
IV.	Health effects of waste water reuse -- isolate & identify organic compounds and trace metals in treated wastewater	$120K/0MY
V.	Recreational water quality criteria -- correlate recreational water quality to various indices of microbial pollutants -- conduct epidemiologic-microbiological studies at 2 N. Y. City beaches (one relatively clean, one barely acceptable) to correlate water quality & incidence of diseases among swimmers -- occurrence of the pathogenic amoeba naegleria, incidence of meningo-encephalitis	$400K/11MY

TABLE II. RESEARCH ON HEALTH EFFECTS OF WASTEWATER AND SLUDGE TREATMENT AND DISPOSAL ($200K/0MY)

- Monitor air, soil and water surrounding a wastewater treatment plant for microbiologic and chemical agents
- Conduct epidemiologic studies to assess possible adverse health effects resulting from the operation of a wastewater treatment plant

The third table compares the water health effects expenditures for this fiscal year ending next month with those proposed for the new fiscal year beginning in July 1974.

TABLE III. EPA WATER HEALTH EFFECTS RESOURCES

	FY-74		FY-75	
	$K	MY	$K	MY
Organics	395	9	700	9
Inorganics	350	13	1150	13
Microbiological	300	13	600	13
Water reuse	120	0	400	0
Scientific summaries	0	0	160	0
Marine recreation	250	8	350	8
Freshwater recreation	150	3	150	3
Wastewaters & sludges	230	1	600	1
Totals	1795	47	4110	47

I believe you can see that EPA is beginning to spend more money on water health effects research. In fact, the projected total expenditure is $4,110,000, or an increase of 130%. This is about one seventh of EPA's total health effects research budget not including the monies which EPA may receive for health effects research and development relating to energy problems. The budget does not include any research directed toward the health impact of sewage sludge incineration, or for directly assessing the impact of water pollution on humans who eat fish, shellfish, irrigated vegetables, or livestock which have drunk water or eaten irrigated foods. However, there are efforts planned which relate to some aspects of these problems.

Full utilization of water pollution control technology would include making the best possible uses of the treated water. EPA recognizes and supports the potential for waste water reuse including agricultural industrial, municipal, recreational, and ground water recharge applications. EPA believes that the potable use of renovated waste waters, blended with other acceptable supplies in resevoirs, may be employed once research and demonstration have shown that it can be done without hazard to health. But EPA does not support the direct interconnection of waste reclamation plants with municipal water treatment plants. This is, in part, because accidental spills or sabotage present an acute threat which cannot be disregarded, since anyone can flush large quantities of any chemical he likes down a toilet. Thus, even if other health problems relating to direct recycling of water are solved, such as viruses, bacterial buildup, chemical buildup, and reliability of operation, the problems of accidential spills or sabotage may mean that some system of holding and dilution resevoirs may inevitably need to be provided between the reclamation plant and the potable water intake, together with biological and chemical monitoring. But this problem is a relatively minor stumbling block compared to the multiple feasible potential uses for treated municipal sewage waters.

Earlier in my talk, I referred to the need for us to determine desirable levels of chemicals in water and in food grown in or by using water other than rain water. Before I finish, I would like to discuss how desirable levels are determined. There is an increasing belief throughout our society that standard setting is not the responsibility of scientists alone, but requires, in addition, the weighing of non-scientific factors. It appears that an administrator trying to decide, for example, a toxic pollutant effluent standard, should have before him several potential standards, the severity and scale of risks of disease or ecological consequences associated with each potential standard, the costs associated with these risks, and the costs of achieving the level of control associated with each potential standard. Only with all these data can an administrator expect to make the most beneficial decision. Public acceptance of a concept of socially acceptable risk and public participation in the standard setting process are highly desirable goals. Such public participation may well be necessary, since highly localized conditions determine what is socially acceptable. Thus, one EPA researcher has recommended that instead of using a numerical criterion such as 200 fecal coliforms per hundred milliliters for all recreational waters, instead a criterion should be used which is a mathematical expression of the relationship of water quality indicators to the probability of illness as well as the social and economic impact of such illness. Such a criterion would be constant, but the acceptable risk might be different depending on the conditions peculiar to the area using the criterion. The standard derived from such a criterion could be expected to become more restrictive as the cost of treatment facilities decreased, or if there were an improvement in the competitive posture of advanced waste treatment facilities for available funding and manpower resources. In some areas, the demand for recreation and the lack of lower risk alternatives might justify a slightly increased risk of illness from swimming. Indeed, the literature demonstrates an increased infectious illness rate among swimmers even in very clean water, when compared to non-swimmers. Thus, the mere fact that we allow swimming at all is because we recognize that the pleasure derived from swimming is worth taking some health risks.

To make the matter even more complex, we must consider the impact of chlorination of sewage waters not only on the swimmers downstream, but on the fish. As we chlorinate to reduce the swimmers' hazard from viruses and bacteria, we increase the hazard of chloramine toxicity to fish. Large fish kills have been attributed to this source. The solution is the development and assessment of additional technological solutions.

Thank you for the invitation to discuss the health assessment of full utilization of water pollution control technology. I hope that these reflections will assist those who develop the technology, and I personally look forward to learning more about the technology as we continue together the never completed task of protecting the public health.

COST-BENEFIT ANALYSIS OF WATER POLLUTION CONTROL

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ABSTRACT

Cost-benefit analysis should be part of the decisionmaking process involving the establishment and subsequent enforcement of water quality standards. An assessment of the economic tradeoffs realized by pollution control provides insight on those standards most beneficial to society. This study begins with a justification for cost-benefit research, and then presents a conceptual outline of basic components in the analysis. The role of technological progress is discussed as it improves the economic welfare of water users. Historically, there has been far greater emphasis on cost than benefit evaluations. As standards become more stringent, however, it is necessary to show that the rising cost burden is worthwhile by increasing net benefits, whether they be quantified in monetary or other units. A survey of the economics literature reveals that national damages from water pollution exceed $12 billion per year. Recreationists, commercial fisheries, water supply users, property owners, and the navigation sector are seriously impacted by degraded water. Although the national estimate excludes important categories, such as aesthetics, ecological preservation, sub-clinical health effects, and nonuser preferences for recreation, its magnitude is great enough to encourage the enhancement and conservation of water resources.

INTRODUCTION

From the viewpoint of national priorities, water pollution control is one of the most important programs for social well-being. More than five years ago when environmental issues began to receive emphasis, the Senate Select Committee on National Water Resources estimated that investments in wastewater treatment would cost about $100 billion by the year 2000. Current annual costs-- including annualized capital, operating and maintenance-- of municipal and industrial waste control are estimated at $5 billion plus.

Because of these seemingly high costs, the question arises as to the worth of such programs. Only in recent times has this question been seriously recognized and Federal funds earmarked for research. The economic test of abatement expenditures is the magnitude of benefits or reduced damages realized by water users. If the marginal benefits of improving water quality are greater than associated costs, then the program adds to net social welfare and is thus worthwhile.

Technology assessment should thus depend not only on the cost of treatment, but also on the effectiveness of this investment to enhance societal welfare. Criteria other than cost-benefit analysis have been proposed and often used for determining the optimal level of control. They include minimizing water use, reducing pollution discharges, and applying economic incentives, such as effluent taxes. But these approaches may not provide the greatest benefits to society. Only by conducting a cost-benefit analysis can these considerations be integrated and the optimal level of control be evaluated.

MOTIVATION

The allocation of funds for wastewater treatment should be designed to elicit maximal welfare gains to society. Since about 70% of all wastewater originates from industrial sources, environmental policies must be formulated to generate these optimal responses chiefly from privately owned orgainzations: heavy and light water-using industries, electric power plants, and combined industrial and municipal sewerage systems. Because many pollution damages are external to the waste generating firm and thus are excluded from that firm's production costs, a regulatory agency, such as the U.S. Environmental Protection Agency, is needed to internalize the damages to the firm, by setting effluent standards or applying other methods of control.

There is no reason, based on actual experience or economic theory, to expect a private organization to engage in socially optimal treatment. In the absence of water quality standards or economic incentives, such as fines and payments or the threat of legislative penalties for inaction, a firm will optimize its profits by transferring input resources from abatement into more profitable manufacturing operations. Market forces are not strong enough to stimulate technological development in order to maximize net welfare impacts of pollution control. If government enforcement proceeds without adequate rationale, then industry and other polluters are likely to win court battles on their right to degrade the environment irresponsibly.

The need for a carefully conducted, comprehensive economic analysis becomes more acute as the level of effluent requirements changes from best practicable technology (BPT) currently available (implemented to 1977) to best available technology (BAT) economically achievable (implemented in 1983). The need to prove economic achievability is directly dependent on a cost-benefit analysis of alternative control strategies. As a result, the level of control must be evaluated in terms of its potential to enhance man's use of water. This will necessitate the stimulation of technological innovation and a more precise assessment of costs and benefits.

Perhaps the most important reason for cost-benefit analyses is a Congressional mandate to do so. Prior to the establishment of any effluent regulation, Section 302(b)(2) of the Federal Water Pollution Control Act Amendments of 1972, require the determination of "the relationship of the economic and social costs of achieving any such limitation or limitations, including any economic or social dislocation in the affected community or communities, to the social and economic benefits to be obtained." Such information can provide guidance for the maximization of net social welfare within technologically feasible ranges of control.

But even prior to the 1972 Amendments, there was interest in cost-benefit studies, although to a lesser degree because of insufficient Federal funding and support. The initiative for this research originated in the mid-nineteenth century with a classic discussion (1) on the utility of public works. By 1946, the Federal Inter-Agency River Basin Committee was given the task of "formulating mutually acceptable principles and procedures for determining benefits and costs for water resources projects." The end product of this venture was the publication of the famous "Green Book" (2), the first economics guideline on project evaluation. In the past several years, empirical techniques have improved considerably as a result of strong public pressures and Federal concern for effective environmental management.

THEORETICAL FRAMEWORK

To achieve maximal benefits relative to costs, one conducts a cost-benefit analysis of alternative control levels. The accuracy and completeness of this analysis rests on the level of effort and quality of resources devoted to the assessment. Of principal concern to legislators are two issues: the usefulness of the analysis in a dynamic context and the economic feasibility of zero discharge, which is the idealized goal of Public Law 92-500.

The first issue addresses the role of technological development in a dynamic context of pollution control. Such advancement shifts the total cost of the control curve in Figure 1 to the right from K_0 to K_1. The optimal control level can be

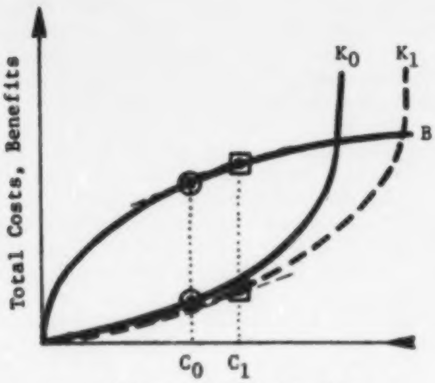

Figure 1. Increasing social benefits by improved controls.

shown from ordinary calculus to be the point where the slopes of the total cost and benefit curves are identical. Assuming that greater unit cost savings occur with new technology, this impact produces a curve below K_0. Thus the economically feasible effluent concentration changes from C_0 to C_1 closer to zero discharge. That is, technological progress on control equipment increases the net benefits (total benefits less costs of pollution control).

The second issue concerns the economic evaluation of zero discharge. This ultimate standard could become the optimal strategy only after substantial technological advance, decreased water procurement costs (through recycling), product recovery, and byproduct sale. At the present time, however, zero discharge is not economically attractive for most industries. Based on a recent study (3), the costs of zero discharge from industrial and electrical power plants would be approximately 3.3 times as much as the present costs of attaining ambient water quality standards. Substantial reductions in control costs will thus be required before total abatement can be justified.

MACRO-ANALYSIS

A macro-analysis of benefits and costs pertains to regional or national impacts, and hence differs from a specific plant, or micro-, analysis. Regional estimates are important because they guide policy on overall government funding tradeoffs among competing societal needs, such as pollution control, health care, and educational programs. Their relatives magnitudes (by pollutant, by region, etc.) can also indicate priorities on technological research as well as point toward potential fruitful areas of future research and development. Because large R&D expenditures can often be supported at the macro-level (e.g., at Federal government research centers), the results of these efforts can benefit research on micro-analyses, which at the local level cannot be supported so generously.

The estimation of regional economic impacts of future control technologies requires the aggregation of all benefits and costs incurred within that area. The relative size of the region can significantly affect the scope of benefit estimation. In small lake and estuary studies, recreation benefits from abatement are likely to compete with those in neighboring areas. But these substitution effects are seldom assessed in the literature. Larger regional, e.g., major river basin, studies are less inclined to ignore these effects. Yet even these estimates may inadequately reflect national impacts.

While benefits are a function of ambient quality, cost curves are derived on the basis of source control. There is thus a basic incompatibility on the scope of variables required to assess these impacts. Benefits are more directly measureable for a region, while costs must be measured at the micro- or firm level and then aggregated into regional totals.

To assess specific effluent impacts requires the disaggregation of benefit estimates by their source, e.g., agricultural, municipal, or industrial effluent discharges. For most regions, this task is very challenging, if not impossible (4). If a sufficiently long time series of water quality data exists, or if there are very few point sources of a specific waste discharge, the identification problem becomes easier. But many benefits are a function of a number of pollutants, so that the separation of pollution effects is practically impossible. To relate benefit changes from ambient quality to variations in emissions requires a reliable water quality model. Such models are available for special pollutants and small regions, but they are not yet developed with sufficient predictive accuracy for more encompassing analyses.

MICRO-ANALYSIS

At the level of the individual firm, costs can be estimated for a range of control levels. But benefits are generally realized in the surrounding environment which receives and assimilates the firm's discharges. In the immediate vicinity of the source, it may, or may not, be possible to attribute damages to specific discharges, since other regional activities can also affect ambient quality, even very close to the source. In general, cost components (for end-of-line treatment) are fairly well-defined, compared to benefits whose evaluations are so often debated in the literature. But over the past two years, Federal support for improved benefit studies has been very encouraging. Both the U.S. Environmental Protection Agency and the National Commission on Water Quality are operating under Congressional mandates to derive empirical estimates of water quality impacts.

COST COMPONENTS

Costs are typically defined and measured to include effluent control and water procurement costs less byproduct recovery revenues. In ordinary usage, then, cost usually means the monetary expenditure allocated to purchase and to operate control facilities. For municipal treatment plants this definition may suffice, but for most industries it is incomplete. There are also costs associated with production changes, which could either include the costs of substituting more expensive inputs, or a decline in profits due to a drop in the sales of certain products. Still unresolved is the problem of allocating costs of process change between abatement and increased productivity. If the change is motivated by the latter goal, even though it may reduce the total pollution load, this decision should be recognized and weighed accordingly. Failure to do so will result in an upwardly biased charge to abatement of the appropriate share of depreciation and overhead expenses from process modification. There is also the related point that today's pollutants may be tomorrow's commercially sold, secondary products. Thus, the cost analyst must be wary of overestimating the costs associated with controls involving such products.

Standard engineering practice in most firms is to presume that a net cost in the range of 2-4% of manufacturing costs is a reasonable range for end-of-the-pipe treatment. Choice within this range is highly arbitrary, however, without knowledge of the specific control technology being utilized and the operating and maintenance requirements thereof.

This engineering approach involves the extrapolation of plant costs from detailed engineering and design specifications of individual treatment processes. The major difficulty is that design engineering costs usually do not correspond to actual installation costs (4).

Another method of cost estimation relies on accounting records. Cost accounts of plants with pollution control activities list capital, maintenance, and operation expenditures. A drawback to this approach is that many companies do not record expenditures in sufficient detail to permit cost determination. Another problem is that for national policy purposes, one is interested in predicting costs of technologies and systems not yet in operation.

BENEFIT COMPONENTS

Benefits are comprised of a monetary evaluation of improvements in health (morbidity and mortality) and welfare as stream quality is improved. Clear water yields a variety of benefits to society, but their value is not always obvious nor can they be easily quantified. Since many water pollutant damages relate to subjective feelings and anxieties, there are no market prices to adequately reflect their values. Nonetheless, the benefits of clean water are real, not imagined, and the protection and improvement of water quality contribute to the social well-being.

The basic frame of reference for benefit quantification is a geographic region, a specific recipient or water use, a water quality constituent, or any combination thereof. The most common objective is to predict total regional benefits of all water-related impacts. In addition to the total estimates, it might also be useful to analyze the distribution of these impacts by population sub-group.

Within this macro-setting, water quality criteria are designed to protect major water users. Streams are classified in many states according to their function in serving the interest of patrons. The sensitivity of the water uses to water quality specifications is reflected in the magnitude of benefits. The complementarity or perhaps incompatibility of activities, e.g., commercial fishing and navigation, underscores interdependencies among benefit recipients. Although water uses are generally responsive to many pollutants simultaneously, standards must pertain to individual water constituents. Consequently, there is a need for benefit studies relating to a single parameter.

Table I depicts a conceptual outline of basic components in an empirical benefit assessment. Each matrix element links the economic damage potential to a water use (column heading) caused by an ambient level of the constituent (row heading). The row and column titles are selected from water quality criteria guidelines.

The weighted pollution index in the bottom row is summed over standard parameters, such as dissolved oxyten, pH, total dissolved solids, iron and manganese, temperature, and total nitrogen. Among all pollution variables the impacts of BOD levels on water use have been assessed most frequently. BOD is usually assumed as a surrogate, or indicator, of the general level of water quality. On the other hand, other pollutants in the table can be identified more uniquely with water use responses.

Consistent definitions of each water use are needed to assess damages. The water supply category includes treatment cost increases resulting from polluted water intake. Navigation is a catch-all term for damages to bridges, piers, and ships, as well as boat accidents and water route closures. Human health can be affected by ingestion of drinking water or by bodily contact with beach water. Other categories are, for the most part, self-explanatory. It is obvious that some water use categories overlap, such as recreation and aesthetics. Mutual dependencies of water uses preclude a complete partitioning of benefit categories. Nevertheless, for purposes of estimation, they are usually considered distinct.

Based on pollutant--water use relationships (5), most of the matrix elements can be documented in terms of physical, chemical, or biological effects. On the other hand, few of these effects have been translated into economic equivalents. The sparseness of economic estimates in the matrix suggests either the non-existence of certain benefits or else the current infeasibility of quantifying the impacts. Economic values have yet to be derived for some benefits in the aesthetic and ecological realm. In evaluating any economic impact, there is quite frequently the problem of segregating multi-pollutant effects. Most benefits are the joint product of a number of water quality parameters and hence cannot easily be apportioned among causative agents.

EMPIRICAL ESTIMATES

Published benefit estimates of water quality improvement are relatively scarce. Most refer to specific regions and cover only the major benefit categories, such as recreation and municipal water supply demand. Furthermore, it is difficult to segregate damages associated with specific pollutants. Most estimates relate to a general index of water quality, rather than to a single constituent.

A survey (5) of the literature reveals that most benefits estimates lack credibility. Many are based on invalid theoretical notions and are not conceptually grounded in welfare economics. There is also a paucity of empirically derived damage functions. Practically all recreation studies, for example, use hypothetical attendance loss curves.

In addition, most empirical findings are region-specific and cannot be easily generalized to other areas. The number of water use categories evaluated is usually small for want of data. Few studies provide explicit formulae or damage equations for general application to other regions. While this deficiency does not negate the theoretical validity of benefit estimates, it narrows the usefulness of the results.

TABLE I. STATE-OF-THE-ART MATRIX ON POLLUTION DAMAGE ESTIMATES

Symbols

■ = economic estimates. ● = physical damages documented.

	Aesthetics	Agriculture	Commercial Fishing	Domestic Water Use	Ecology	Human Health (Ingestion)	Human Health (Water contact)	Industrial Water Supply	Municipal Water Supply	Navigation	Power Generation	Property Value	Recreation (Water Contact)	Recreation (Water Non-Contact)
Acidity	●	●	■	●	●	●		■	■	■	●		■	●
BOD	●	●	■		●			●	■			■	■	■
Coliform Bacteria	●	●	■		■	■	●	●	●				■	●
Color	●		●	●				●	●				●	●
Floating Solids	●	●	●		●			●	●	■		●	●	●
Hardness	●	●	●	■	●			●	●					
Nutrients	●	●	●		●	●		●	●		●	●	■	●
Odor	●		●			●		●	●			●	●	●
Oil	●	●	■	●	■			●	●	●	●	■	■	●
Pesticides	●	●	●		●		●	●	●				●	●
Radionuclides	●	●	●		●	●			●				●	
Sediment	■	■	■		●			●	■	■	●	■	●	●
Taste			●			●			●				●	
Temperature	●	●	●	●	●			●			●		■	●
TDS & Salinity	●	■	●	■	●	●		●	●		●		●	●
TSS & Turbidity	●	●	●	●	●	●		●	●	●	●	●	■	●
Toxic Metals	●	●	■	●	●	●		●	●		●		■	●
General Pollution	■	●	■	●	■	■	●	■	●	■	■	■	■	●

Even if benefits could be measured accurately, difficulties arise in using them to justify water quality standards. Since a poor person is generally less willing to pay for water-related services than his wealthier counterpart, should his benefits also count less? Water management programs can be designed to increase total benefits and/or to redistribute impacts by emphasizing water uses associated with special income groups. For the latter objective, it is important to measure the distribution of benefits (and costs) among the population and also among geographic areas.

Table II summarizes annual estimates, as of mid-1974, for damages to human health, materials, outdoor recreation, production costs, and property value. The best estimates of water quality benefits were compiled and aggregated, wherever possible, into national values. In some instances, only regional or case study values could be ascertained. Empirical results are not yet available for aesthetic and psychic benefits.

Human Health

The protection of human health has traditionally been the primary objective of water quality enhancement. In spite of a long historical period of concern for drinking water standards, the extent to which most pollutants are harmful via the water routes is unknown.

Liu (6) estimated the impact of enteric viruses on acute clinical illnesses, such as infectious hepatitis, acute gastroentiritis, and congenital heart anomalies. The author admitted that these estimates are crude, but at least they were preceded by an extensive literature search on outbreaks and sporadic cases of water-related illnesses.

In the prevention of tooth decay, fluoridation is beneficial to man's health. Conservatively, a savings of $30 per year is realized by fluoridation for a typical child. For the nation, such savings are translated into total benefits exceeding $1.1 billion, given data on fluoride levels of public water supplies (7). On the other hand, excessive fluoridation can lead to fluorosis, which is quite expensive to treat.

TABLE II. ECONOMIC DAMAGES FROM WATER POLLUTION IN U.S., 1970

Type of Damage	Estimate (Millions)
Human Health	
Viral-related, clinical	$ 374
Tooth decay	1,100[a]
Preventable illness	300
Materials Damage	
Ohio River Basin	2[b]
Sediment depositions	260[c]
Household damage	600 - 3,450
Navigation damages	20
Outdoor recreation	
Fishing	2,240
Boating	1,620
Swimming	3,760
Waterfowl hunting	30 - 90
Commercial fishing	12 - 65
Industrial water supply	430 - 620
Appalachia	1.2[b]
Illinois	24
Ohio River Basin	56
Municipal water supply	
Ohio River Basin	25
Illinois	4
Agricultural water supply	
Colorado River Basin	16[d]
United States	800[e]
Property Values	33 - 175

[a] Not necessarily caused by water pollution.

[b] Acid mine damage.

[c] Flood plain damages, storage losses in reservoirs, navigation channel closure, commercial fishery losses.

[d] Irrigation water constituents, salts.

[e] Plant nutrient losses from erosion and sediment.

Another study (8) anticipated monetary impacts of drinking water contaminants on preventable illnesses. Economic values are based on typical costs of medical treatment and time lost from work. These illnesses differed somewhat from the above by including low-level gastroentiritis and non-viral related incidents. However, the illness rates were based on a questionable extrapolation of reported cases, to account for unreported outbreaks.

These estimates, based on medical costs and worker absenteeism, are likely to be conservative since they exclude work days below full productivity and efficiency. There are also low-level illnesses, such as the common cold or influenza, whose economic impact per individual may indeed be small but in the aggregate could easily run into millions of cases annually. Psychic costs of suffering and anxiety are perhaps even more difficult to quantify. Besides direct ingestion of water, there are dangers from recreation in contaminated water. Unfortunately, the few empirical studies published on this topic are contradictory.

Materials Damage

From an economic perspective, corrosive and abrasive pollutants have significantly damaged materials in direct contact with water. Materials damages can be distinguished according to their original point of occurrence. With respect to instream activities, polluted water bodies are responsible for accelerated depreciation of bridges, wharfs, and piers; blockage of navigation routes; and increased repair of ships and other floating vessels. With water withdrawal activities, damages occur to appliances and plumbing facilities in households as well as intake water distribution facilities in municipal and industrial plants.

One of the earliest benefit reports (9), in 1943, estimated the economic losses of corrosion from acid mine drainage in the upper Ohio River Basin. Annual damages totalled more than $2,000,000 to domestic and industrial water suppliers, steamboats and barges, power plants, and river and harbor structures. At that time, recreational and aesthetic damages were considered unmeasurable, although their values were surmised to be at least as large as those measured.

Damages caused by floating debris are a continuing problem in major shipping areas. Typical costs to owners of boats colliding with debris are rarely mentioned in the literature. But the Corps of Engineers, as part of its harbor maintenance program, estimated losses to the twenty largest U.S. ports at almost $20 million (10). These costs pertain to repair and maintenance of damaged ships, both commercial and recreational, but they exclude the value of time delays from accidents and health costs from human injuries or, in a few cases, fatalities. They also neglect damages in smaller ports, public recreational areas, and private marinas.

National estimates of damages from sedimentation and erosion are available, but they are highly suspect because of the intuitive nature of the data. Sediment loads are usually from non-point sources, and hence their diffusion and transport in water cannot be accurately monitored. The source of sediment discharges cannot be accurately traced, although a large fraction of total loads is due to natural processes of erosion or originates from land developed for agriculture and lumber production. To identify that portion due to human activities is currently infeasible. The value of plant nutrients removed by soil erosion in this country is estimated at $800 million annually (11). Sediment particles are responsible for an additional $260 million, of which $50 million is flood plain damages; $16 million, irrigation ditch obstructions; and $11 million, damages to hydro-turbines and commercial fisheries. Because these are crude estimates, they must be interpreted with caution.

Household appliances and personal items in daily contact with water supply are subject to damages from chemical and other constituents in the water. These damages were translated (12) into economic losses for a typical household, and then aggregated at the national and individual state levels. In the United States, total 1970 damages to household items were in the range of $0.65 - $3.45 billion, with a mean of $1.75 billion. Those states with the highest mean estimate of damages include California at $230 million and Illinois at $164 million. Per capita damages are highest for Arizona, $22.53, and New Mexico, $18.58. The most damaging pollutants are hardness and total dissolved solids. Water quality data by supply source were obtained from state water resources experts, whose personal assessments may introduce biases into the calculations.

Outdoor Recreation

Recreation benefits have often been cited as the most important objective of water quality legislation, aside from the protection of human health. Economic theory and consumer behavior suggest that there are at least five distinct types of recreational benefits: (1) a potential reduction in price (travel cost) to current users, primarily fishermen, boaters and non-pool swimmers; (2) an expansion of water-based activities from this lower price, both on the part of existing and new users; (3) a shift in the quality of the recreation experience; (4) a preservation value that a large group of nonusers attach to the conservation of waterways in their natural state, even though these individuals have no intention of ever using them for recreational sports; and (5) option value that nonusers attach to the increased likelihood that they will be able to recreate in natural waterways, should they decide to do so in the future.

A recent survey (13) of the recreation literature concluded that past studies have understated economic benefits because they developed empirical estimates for only one or at most two of these five types of impacts. Empirical findings indicate that, on a national scale, recreation benefits from water quality enhancement exceed the combined gains to commercial fisheries, property value, materials corrosion, and water supply to the housing, industrial, and agricultural sectors. But whether they are greater than human health losses including sub-clinical cases remains to be proven.

Benefit numbers listed in the table were based on documented assumptions concerning: (1) the amount of polluted waterway to be restored for recreational activities; (2) changes in the recreation behavior of consumers as water quality changes; and (3) the price or willingness-to-pay for water-based outdoor recreation activities. Among the major sport activities, beach swimming gained the largest share, almost half, of all the benefits. Fishing gains were realized in fresh water (almost 80 percent of total benefits) as well as salt water, especially in polluted estuaries (20 percent).

These estimates, it must be noted, pertain only to the first three types of welfare impacts, namely, the reduction in travel cost to more accessible water bodies, increased demand from participants, and enhanced value of the recreation experience. These respective categories accounted for 54%, 12%, and 34% of all benefits. Of course, these values are preliminary and will be revised as more data are published.

Production Benefits

Commercial Fishing

Roughly one-fifth of marine shellfishing areas in the United States are closed because of pollutants, primarily high fecal coliform or BOD levels, although toxic metals have also affected the industry. Most published estimates of commercial fishery losses are for localized problems, although three national estimates have been made. Two (14, 15) of these estimates are based on decreases in potential catch, as the landing price remains constant; the third (16) assumes that price responds to supply changes and then estimates the total change in willingness-to-pay by consumers of fish products. The lowest estimate considers only clams and oysters as being harmed by pollution, while the upper one also includes lobsters, shrimp, and crabs.

Industrial Water Supply

Treatment costs of water intake by industry are well documented in the literature, but they generally depend on water quantity rather than quality. Nevertheless, there are a few regional estimates of the costs of chemical additives as water quality changes, holding other factors constant. There are no national damage estimates because of difficulties in extrapolating local estimates, based on a particular industry mix and water pollution problems.

In Appalachia, a ninety percent reduction of acid mine drainage at the mine source would imply a savings of $1.2 million in lime neutralization (17). At least two regional studies (17, 18) concluded that the elimination of all natural pollutants in water would yield benefits in the tens of million dollars. Assuming that less chlorine and other chemicals would be required, an estimate for the state of Illinois is $24 million. Another study (19), of the Ohio River Basin, arrives at a total of $56 million as a result of less filtration, softening, clarification, and demineralization. But these estimates are based on simplistic assumptions, such as fixed unit costs of treatment processes and the use of certain treatment technologies. Extrapolating these figures to the national level yields a range of $430 - $620 million in damages.

Municipal Water Supply

Treatment costs of municipal water supply have been shown to increase as the quality of intake water worsens. There are few regional estimates of economic losses from water treatment. Those available show wide ranges of values on a per capita basis, due primarily to differences in assumptions on the number and types of treatment processes necessary to control pollution.

In the Ohio River Basin, added annual costs of water treatment attributable to water quality factors were estimated (19) at almost $25 million or $1.25 per individual, on the average. These costs exclude treatment of ground water, which was thought to be primarily natural in origin. The latter opinion is strongly refuted by most hydrogeologists. In a state report (18) for Illinois, cost savings of water quality control were estimated at $4 million annually, or $0.35 per capita. But this estimate excluded treatment of Lake Michigan water supply, which seems incorrect in view of the lake's partial contamination by man-made activities.

Another empirical study (20), in the Chicago metropolitan area, found damages from dredging to be very minor at less than $10,000 per year for the entire urban population. This estimate is much smaller than the above because it is concerned with a minor pollutant, dredge spoils, compared to a myriad of pollutants normally treated in a municipal plant.

Agricultural Water Supply

In farming activities, economic damages are identified primarily with dissolved salts and bacterial content of irrigation water. Deleterious effects of salts on plant growth can result from osmotic effects or prevention of water intake, or from chemical effects upon plant metabolism. Coliform bacteria can contaminate food crops, although they seldom cause serious problems in the United States.

Economic damages are usually measured as the revenue or farm income lost from reduced crop yields and increased operating costs. At high salinity levels, only certain crops can tolerate the chemical effects of irrigated water.

In the Colorado River Basin, 1970 annual economic losses from salinity were estimated at $16 million (21). By 1980, this estimate is supposed to increase to $28 million, unless corrective actions are taken. But the method of estimating these damages has been criticized for assumptions adopted about crop response to salinity and about options available to farmers to handle salinity problems.

Another study (19) concluded that damages in the Ohio River Basin are negligible because the total annual value (cost to farmers) of irrigation water subject to pollution impacts is below $60,000. But this conclusion is based on the cost of water rather than crop damages that it causes.

Property Values

It has been clearly demonstrated that as water quality improves over time, people are willing to pay more for property near the water. An estimate (22) of national benefits to property owners showed that improved water quality increases property values an average of 8 - 25 percent. In aggregating from case studies to the national level, estimates were obtained for metropolitan (18 percent), town (17 percent), and rural areas (65 percent). Sale prices and tax assessments were used to measure the property values before and over a time interval of ten years.

Other studies (23, 24) also reached the general conclusion that water quality affects property values. Benefits ranged from 5% to 15% of original property value, but were no more important than other determinants in affecting values along man-made lakes.

CONCLUSION

This paper has addressed some of the theoretical issues underlying cost-benefit assessments of water pollution control, and has related them to the impact of technological progress. Because far less attention in the literature has been devoted to benefit than cost analysis, the former topic is emphasized.

In the past, cost analysis has received far more attention than the benefit issues. But even published cost data narrowly focus on end-of-the-pipe treatment, to the exclusion of process change impacts, social costs of unemployment, and secondary cost impacts to the regional economy. Benefit studies have appeared more frequently in the last two or three years, but the state-of-the-art on estimation varies considerably with respect to each water use category.

Quantifying the benefits of water-based recreation has been the subject of considerable effort over the past decade. While progress is notable, particularly on the theoretical side, many benefit values, such an nonuser demand, remain to be examined. Aesthetic and ecological benefits, frequently ranked with high priority in water resource developments, remain elusive of economic evaluation.

Health effects have been monetized for certain illnesses, but these estimates are conjectural at best. There is considerable disagreement among economists about the value of human life and the costs associated with pain, suffering, and anxiety.

Property value estimates are usually based on reasonable statistical techniques, and empirical findings are quite consistent among the best-known studies. For the analysis of production benefits, e.g., with commercial fishing and water supply users, the methodological framework is fairly standard and data bases can often be obtained. Yet empirical work is severely limited to a few references.

Despite these deficiencies, national damages have been estimated here for important water uses. Preliminary results indicate that these impacts exceed $12 billion annually, excluding nonuser benefits from recreation and intangibles, such as aesthetics, ecological stability, and wildlife support. Many public opinion surveys have underscored the social importance of preserving or enhancing these values. It is thus apparent from a cursory analysis that water quality control is indeed worthwhile to national welfare, and it should therefore be pursued vigorously so that society can realize these potentially large benefits.

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GUIDING TECHNOLOGICAL AND SOCIAL CHANGE

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ABSTRACT

This paper examines concepts which contribute to a deeper understanding of how to guide technological and social change. Technology assessment requires social assessment utilizing knowledge of how social systems change. Social indicators are one important method of obtaining information about social change. Methods of guiding change and managing conflict are also reviewed. Contributions from the social and behavioral sciences suggest that a "socio-technical" systems analysis will be more useful in technology assessment in the future.

Measuring the impact of pollution control technology is a form of technology assessment and guidance of social change. Technological changes can be social interventions. Consequently, a new technology may require analysis of its present and future effects upon physical and biological environments, and upon human social communities and individuals. This perspective requires not only the physical and biological sciences, and engineering, but also the social and behavioral sciences.

TECHNOLOGY ASSESSMENT

According to one view (from "Technology Assessment for the Congress" prepared by a subcommittee of the Committee on Rules and Administration, United States Senate, GPO, 1972), "Three key questions arise in the technology assessment process: Where do we want to go? (goals); where are we most likely going? (forecasting); and where are we now and how are we doing? (social, economic, environmental, and other indicators) . . . . The purpose behind all these forward looking activities is to direct planning efforts toward creating desirable situations without the undesirable effects. . . . Sociology, anthropology, psychology, mathematics, engineering, ecology, and the policy sciences demonstrate man's new power to understand, forecast and sometimes manipulate those forces which influence his social and physical environment."

One example of technology assessment methodology developed by the Mitre Corporation for the Office of Science and Technology identifies seven steps:

1. Define the assessment task.
2. Describe relevant technologies.
3. Develop state-of-society assumptions.
4. Identify impact areas.
5. Make preliminary impact analysis.
6. Identify possible action options.
7. Complete impact analysis.

SOCIAL AND BEHAVIORAL SCIENCE METHODOLOGY

The social and behavioral sciences enlarge the "state of society assumptions" in the third step. The methods presently available for social system analysis, attitude measurement, and analysis of the social "ecology" of communities comprise alternative forms of analysis. Social indicators used to monitor over time the social impact of a technological innovation are especially useful. Social indicators promise to become a forecasting methodology to determine how changes in human communities are affected by proposed technology. According to Parke and Sheldon (1972, p. 100), such an indicator is ". . . (a) statistical time series that measure changes in significant aspects of society. . . .a prerequisite to the advancement of social indicators, however defined, is the scientific measurement of social change." An important part of technology assessment is, consequently, measuring technological impact on social change.

Prediction of the multiple effects of complex technology upon a social system using social indicators may have to go beyond empirical studies. A social system theory is also necessary if a social indicator is to be used effectively. Social indicators reflect an underlying social structure said to be undergoing change in a community. The elements of such a social structure are not easy to determine because there is apparently no uniform opinion about how to characterize it. Sheldon and Freeman (1970, pp. 102-103) argue that "There is no social theory, even of a tentative nature, which defines the variables of a social system and the relationships between them. It is difficult to locate partial theories or so-called middle-range ones covering any single aspect of society which have convincing explanatory potential. Yet, without the guidance of theoretical formulations concerning significant variables and their linkages, one can hardly suggest that there exists, even potentially, a set of measures that parallel the economic variables." While technical problems such as scale construction, experimental design and the like are important, theory development is an urgent overriding need. Sheldon and Freeman (1970, p. 104) recommend that "With more knowledge on what to measure and better operational measures, work on understanding the past and predicting the future would be made more effective."

If analysis of social systems can proceed forward in a complimentary way with increased methodological sophistication, then social indicators may "contribute (1) to improved descriptive reporting; (2) to the analysis of social change; and (3) to the prediction of future social events and social life" (Sheldon and Freeman, 1970, p. 103). The three levels of analysis all seem to be relevant in technological impact analysis.

IMPORTANCE OF AN ECOSYSTEM VIEW

A comprehensive ecological theory of social system change is necessary in technological impact studies. Some elementary forms of social change in complex human communities, for example, are like those among lower organisms in their ecosystems. The concept of the "food web" of feeding interrelations has a counterpart in complex human communities in the "resource web" or "resource network" in which a resource commodity may be simple ingestible food or forms of usable energy such as gasoline, fuel oil, natural gas, electricity and atomic fuels. The fuel shortage is a recent example of the dramatic effects on social behavior of major reductions in portions of the United States resource network.

Another example is "convergence" (or maturation) illustrated clearly in edaphic series which range from so-called pioneer to climax ecosystems. Programs of pollution control suggest optimistically that a technology intensive aging process in an ecosystem can be reversed. If this is true, then should we not be able to find that some forms of social reversal of aging may occur in related human social systems at the same time? Cleaning up lakes and streams may initiate public demand for recreation which in turn may set in motion renewed social interaction and economic activity with second and third order social benefits.

Synecological effects (i.e., interrelations of natural grouping of populations and communities) also may be quite far reaching as efforts are made to reverse the aging process of human societies which are a result of wear and tear on society caused by technology.

Social and technological stratification is still another consideration. Much more could be known about the forms of pollution control efforts upon the vertical series, or social strata, of human communities. Benefits to one social group, for example, cannot be assumed to occur across the board. Questions of social and legal equity and questions of social and political organization are raised. The social goal of "the greatest good for the greatest number" poses logical and value problems associated with distributive justice which are hard to resolve and which need reinterpretation in the light of present values.

Tradeoffs in resource allocation from control programs to reduce social costs of technology to some groups and organizations may not be successfully applied in all cases. Pollution control programs may spread this social cost too narrowly among some social groups or too widely among others. The issues this problem raises are philosophical and ethical as well as social-psychological.

Social changes arising as a consequence of "resource web" disruptions may seriously affect the economic survival of individuals in the "intergrading" areas which comprise ecotones or marginal zones in an ecosystem. For example, independent automobile service stations were the first to disappear when the gas shortage struck. Poorer people who live in lower socio-economic areas in the vertical series in the ecosystem usually are hurt first by the price increases created by the disruption in the resource web. Such people will not be able to pay for, and obtain, gasoline should it reach one dollar per gallon.

Moreover, studies of the formal, administrative, nonpsychological structures of a social system are often misplaced analyses. Changes in human behavior often go unnoticed. Synomorphic analysis of the behavioral space of a human community yields quite a different order of information about important social relationships (see the work of Barker, 1968). It is not surprising to find that a change in a physical environment by control of a pollutant will not at all affect the formal structure of, say, a family or larger social organization, but may change dramatically the type and intensity of informal day-to-day behavior. We are all familiar with the fact that a classical organization chart may contribute very little to understanding actual work behavior of people in an organization.

Finally, comparative analysis of the ecological equivalence, or differences between communities, may help us to understand positive or negative changes in social behavior occurring after changes in the physical environment. Often we do not know ahead of time which technological changes result in beneficial social effects because we do not understand the principle of ecological equivalence. The people of a given socio-economic level in one community may or may not share the needs and problems of the same socio-economic level in another ecosystem. The assumption that they do may be wrong. All poor people do not have the same needs, nor do all wealthy people, all other things being equal. They may vary in the periodicity of their needs which are invariably correlated with changes in such resources as food and energy. The question of the effects of such change upon resource use would seem to be an important one to ask.

These considerations can affect the kinds of social indicators which may be developed to improve social reporting, analyze social change, and predict future social events and social life as it is affected by technological change.

THE RANGE OF SOCIAL INDICATORS

Land suggests that one can view social indicators as "output descriptive" which measure the end products of social processes, "other descriptive indicators" which are general measures of social conditions and changes, and "analytic indicators" which are components of models of social processes resulting in the values of output indicators (see also Sheldon and Land, 1972, p. 139). The last one illustrates the problems of theory development discussed above.

Sheldon and Land (1972, p. 146) also list social indicator content areas which has some bearing upon the range of social events which we may wish to view in relation to a given technological assessment. The list is obviously not exhaustive for our purposes and its eclectic form misses the theoretical mark. Under "socio-economic welfare" they mention population (composition, growth and distribution), labor force and employment, income, education, health, leisure, public safety and legal justice, housing, transportation, physical environment, social mobility and stratification, and knowledge and technology. Under "social participation and alienation" are included family, religion, politics, voluntary associations, alienation, use of time, consumption behavior and aspirations, satisfaction, acceptance, morale, etc. Land remarks that "While there is nothing inherently wrong with such a procedure, especially at this stage in social indicators research, it fails to provide a rule for the systematic refinement and augmentation of the list, and it certainly provides little in the way of guidelines for the analysis of social change."

Social indicators, therefore, should be encouraged in technology assessment because they will increase knowledge of the effects of technology on social life and are useful in planning and monitoring change. Limits of space preclude further discussion of a variety of technical issues, such as attitude measurement (e.g., Maloney and Ward, 1973, discuss an interesting objective scale for measuring ecological attitudes and knowledge), data collection methods, and experimental or study design which will have special relevance in sociotechnical systems analysis. There are also a number of related problems of policy impact analysis including the value of using rigorous experimental designs to guide social experiments in technology assessment. Volumes and papers by Rossi and Williams (1972), Campbell (1971), Seashore (1973), and Webb, Campbell, Schwartz, and Sechrest (1973) serve as examples.

GUIDING TECHNOLOGICAL CHANGE

Guidance of change requires rational planning and wider citizen participation, and knowledge of the limitations of such planning and participation. One thing seems to be clear. Guiding change is sufficiently complex to require attention in and of itself. I favor the term *guidance of change* rather than management because in this complex work tasks are often highly consultative and communications intensive rather than directive and controlling in the older, classical, management sense. Very often control over procedures and effects is a consequence of a mixture of problem solving behaviors, rather than a single kind of directive administrative or legal action. Jurisdictional and legal boundaries and constraints, moreover, require flexible utilization of methods which cut across diverse social organizations and groups. Thomas and Bennis (1972, p. 11) warn that one often "cannot afford the illusion of total mastery over change which many technocratic approaches seem to imply; nor can (one) afford that brand of fatalism which can cause us to give up attempting to implement the *planning for change* ethos necessary. . . ." One interesting paradox offered by Eric Trist called the "planners dilemma" urges us to reconsider the methodological issues management of change raises. Trist says that ". . .the greater the degree of change, the greater the need for planning--otherwise precedents of the past could guide the future; but the greater the degree of uncertainty, the greater the likelihood that plans right today will be wrong tomorrow" (quoted in Schmidt, 1970, p. 29).

At the heart of guidance of change are three fundamental elements: adequate information and knowledge; viable communication or information systems requiring an appropriate degree of citizen participation; and flexible decision rules comprising a strategy for utilizing these elements. I should like to illustrate some decision rules which contribute to guidance of change. Some are sequential requiring, as does the critical path analysis, a deliberate sequence of acts to be performed. I have paraphrased one view of change guidance which recommends five initial steps (Mann and Neff, 1961). Those who have an historical interest may recall that a significant amount of prior conceptual work has been done including earlier pioneering efforts by Kurt Lewin (1958) and William Fielding Ogborn (see his selected papers, 1964), and work in social psychology and sociology.

The state of a community or social ecosystem before technological change. This amounts to a social system analysis which may involve a partial or complete study of some morphological and functional aspects of life styles. I have referred above to the term *social ecosystem* which is a preferred unit of analysis for reasons given earlier. The focus of a given analysis is determined by the character of the technological change to be introduced. In some cases, use of social indicators may suffice, in others more comprehensive analyses may be required.

Recognizing a need for change. Psychological readiness for change is important to determine. One must assure that individual motivation is reasonably high to search for innovative solutions to a problem and that a problem is recognized initially.

Planning for change. Setting objectives, clarifying the problem and defining it, developing alternative courses of action, strategy and tactics, identifying and developing needed skills, obtaining information and knowledge, and designing information systems which determine the required degree of citizen participation. In this connection see the volume *Planning* for Innovation (Havelock, 1971) which discusses a variety of methods.

Taking action steps to make the change. Action is taken to execute the change plan through appropriate degree of involvement of the public and others, creating methods for monitoring the change by utilizing appropriate social indicators, replanning where necessary, and formation of new action steps.

Stabilizing change. It is important to act to consolidate and to reinforce patterns of behavior and fulfill public expectations required under a new system. This is no less important than the other four conditions since there never are built-in guarantees in any new program that it will not seriously be affected by changes in the ecosystem in the future, especially those which are political and economic.

This approach recognizes the vital importance of citizen participation in the actual process of change. Without emotional and intellectual commitment to new ideas it engenders there can be no long-term commitment to the change. An atmosphere of trust and openness in communication and mutual planning and action is a key to sustained public support for programs of technological change. It is important to reaffirm that methods of change are as important for success as is the object of change. Ends do not justify means because the means will affect the ends in far-reaching unanticipated ways.

Four additional points about the guidance of change are noteworthy. There is first an effect created by the psychological, social and material rewards brought about by the change, as well as by disappointments. Motivational effects of change are important to consider. Closely related is the timing of the change process. Rapid change will have adverse motivational effects which are irreversible. They may create deep-seated resentments which will limit future programs of technological change. Third, social power, and its many political forms, will play an important part. Ignorance of the "realpolotik" of social change is an important cause of failure of change efforts. Fourth, complex organizations are interconnected systems, some elements of which will affect the behavior of others. Obvious as it may first appear to be, failure to take into account other relevant systems which affect the one to be changed contribute to the probability of failure.

A summary of decision rules which apply to the guidance of change are reproduced in Figure 1. While the term management is used in the text of the figure, the decision rules also apply to the concept of guidance of change.

MANAGEMENT OF CONFLICT

In the course of guiding complex technological change, responding to dissent through the resolution of group and individual protest may become a critical issue. Consequently, it may be useful at this time to discuss some principles about the management of conflict. The following remarks are adopted from an earlier paper (Lundstedt, 1970).

Kenneth Boulding (1964, pp. 138-145) makes a useful distinction between two elementary social acts which occur in adversary relations called conflict moves and trading moves. Successful trading results in both parties gaining something. Conflict results in gains for at least one party and some losses for the other. Occasionally both lose. Mutual loss is a special outcome of conflict behavior in which neither party may have full control over a final outcome. Conflict can have a "win-lose" quality.

Fortunately, all conflicts are not irretrievably hopeless. They are usually changed into mutually beneficial trading by compromises and sharing of benefits. Negotiation and bargaining, strictly speaking, is a procedure by which a particular conflict field is explored to find the best available and mutually beneficial trading moves. As soon as all available trading moves in a particular field of conflict are exhausted, the parties are left with an "irreducible minimum" of conflict. If the leftover conflicts are unimportant to the further survival of either party, each may lose interest in the issue at hand. If the remaining conflicts are serious enough, the conflict relationship between the two may continue to evolve and may become a crisis and deadlock. New methods of conflict management are then imperative. The "relevant states," or value systems in the conflict field often have to be reexamined to find ways to break the deadlock.

Figure 1

Strategies for Managing Change

(-) ← Management's Estimate of Impact of Change on Individual → (+)

(+) ↑ The Individual's Estimate of Impact of Change on Him ↓ (-)

	Estimates as incompatible with individual's personal goals	Don't know	Estimates as compatible with individual's personal goals
Estimates as Self-Enhancing (compatible with personal goals)	(A) When finding Support and Acceptance: Start scaling down expectations to realistic basis so that disillusionment is not destructive	(D) When finding Support and Embracement: Provide individuals with knowledge that course of change is not fully predictable	(G) When finding Embracement and Support: No problems except to maintain favorable definition of change
Don't Know	(B) When finding Resistance: Begin to review objectives and give information about the change to reduce ambiguity	(E) When finding Resistance: Provide full information about necessity for change as seen by management Share control in putting change into effect	(H) When finding Resistance: Increase information about change to reduce ambiguity
Estimates as Self-Destructive (incompatible with personal goals)	(C) When finding Opposition: Review change objectives Change objectives or Change personnel (Change would have to be made in period of power imbalance in favor of management)	(F) When finding Opposition: Provide full information Share control in putting change into effect	(I) When finding Opposition: — Increase information about change and its implications — Recognize that climate of trust is unfavorable — Identify and publicize how steps being taken are compatible with individual goals--distinguishing this change from others in the past

From: Mann, F. and Neff, F. Managing Major Change in Organizations. Ann Arbor: Foundation for Research on Human Behavior, March, 1962.

Social attitudes and motivation are obviously helpful in understanding social conflict. If we should ask why conflict and trading occur between individuals and groups, psychological concepts are required to help explain the source of an action. Conflict and trading are always motivated behaviors and a key to understanding them is to know the extrinsic and intrinsic motives behind the behaviors.

Conflict and trading behavior are said to be motivated by expectations and emotions associated with reward or punishment. Experimental research and common sense overwhelmingly support the interpretation that people are attracted by the promise of pleasure and the reduction of pain. This fundamental point is important. Pain irritates, angers, and then repels or provokes attack and is a basic source of conflict. Conflict and trading are also "motivated" by reasoning and reasoned choices among alternatives, especially in the selection of avenues for achieving personal or group goals which appear rewarding.

We commonly think about social relations and conflict not only in terms of an anticipated future, but also in terms of immediate and past memories (both emotional and intellectual) of earlier pleasure or pain encountered in conflicts with others. Conflict and trading behavior reflect the influence of long- and short-term memories in ways which are subtle and far-reaching. As for plans and anticipation, it is fair to say that most people regard the future in terms of a subjective probability wherein either winning or losing in a conflict is expressed along a scale of values in which emotionally laden long- and short-term memories of former reward and punishment play an important part.

Only when minimal human requirements for survival have been met can generosity and cooperation begin to take on extensive concrete meaning. Paradoxically, though, under some limited conditions people may be able to express these sentiments even when deep dissatisfaction and personal suffering are evident. People will, on the average, express humane social wants and sentiments even under severe duress provided, of course, that too much duress does not exist.

Providing cynicism is not too overwhelming, generosity also leads to increased generosity and reciprocity. George Homans (1958, p. 597) correctly tells us that human social exchanges are even a form of "economic" reciprocity.

Reward and punishment also markedly affect the emotional depth of intellectual commitment. In trading, when one is consistently rewarded, thoughts about one's adversary should tend to become favorable. When two or more parties continue to be mutually rewarded the relationship between them eventually should improve. It is important also to indicate that use here of the terms "reward" and "punishment" does not imply any commitment to a particular theory of behavior, such as behavior modification or the like, and is merely a use of the terms in a generic psychological sense.

When we think, feel, and prepare to act toward someone or something we are said to have an attitude toward it. These three elements form the structure of a single attitude, and, thus, an aspect of our psychological posture toward something or someone. Thought, feeling, and a readiness to act are obviously of great importance in understanding conflict and trading behavior, and ultimately conflict management. We know a great deal when we understand the true attitudes of others, and, accordingly, we can manage relationships better by anticipating others' needs. On this sound basis we can examine more thoroughly common mistakes and alternative methods of confrontation and problem solving.

Two common errors are indicated in Figure 2.

TWO METHODS OF CONFRONTATION

Dueling

This method of confrontation has been inherent in generalized conflict. The inevitable "win-lose" quality that arises in dueling contributes to cycles of behavior that often lead to patterns of mutual destruction. Since each will work only in terms of his own self-interest to the exclusion of the other, each may become irrevocably trapped within this blind alley which so decidedly shapes the final outcome of such conflict and sets narrow limits upon opportunities available for its resolution. People, groups, or organizations can hardly be expected to bargain rationally

Figure 2

Attitudes and Conflict Management

		But the actual attitude of your adversary toward you is: + Positive and Favorable	 − Negative and Hostile
Your initial attitude toward your adversary, and your interpretation of his attitude is:	+ Positive and Favorable	Probable Outcomes: Trading Conflict resolution, Increased Communication and Generally productive relations	Type A Error in Decision-Making Probable Outcomes: Disruption in trading due to miscommunication and confusion of motive. Higher probability of hostility and conflict unless corrected.
	− Negative and Hostile	Type B Error in Decision-Making Probable Outcomes: Disruption in trading due to miscommunication and confusion of motive. Higher probability of hostility and conflict unless corrected.	Probable Outcomes: Hostility and Conflict

in the face of hostile attitudes, mistrust, and anger that are aroused by mutual punishment. Indeed the dilemma has been called a form of "conflict trap." Hostile duelers often cannot abandon a pattern for fear of loss of face, status, or property.

Paradoxically, variations upon this style may represent only a slight improvement so that quantitative deescalation may not in fact equal qualitative deescalation.

The psychological limitations of this method of social problem solving are qualitatively similar. Threats to survival inevitably force contending parties to adopt the inexorable logic of defense and offense. The locked-in quality of the "win-lose" frame of mind strangles efforts to find avenues for productive bargaining, and the cycle of dueling and mutual destruction remains essentially unchanged.

Mutual Problem-Solving

Collective bargaining attempts to remove a qualitative psychological barrier in dueling behavior because it reflects a change in attitude toward one's adversary and in the motivational bases for action. The requirement of negotiation in many modern conflicts has set the stage for mutual problem-solving leading to intelligent trading behavior. The special conditions for such an outcome involve not only a conscious effort to abandon open hostile dueling, but efforts to promote the development of mutual trust. But we may ask, what in addition to mutual trust is the major difference between such problem solving and the other patterns of conflict management? What can one expect to find in this pattern and not in the others? Initially, the motivational basis of conflict management has changed from mutual punishment to mutual reward wherein the cultivation of positive attitudes toward one another is seen as valuable and necessary in its own right.

Control of threat and anxiety is an initial qualitative difference in mutual problem solving. Anxiety has not always been correctly interpreted. At times it has been called an unnatural element in behavior, an interpretation formed no doubt from clinical observations of its dysfunctional aspects and their effect upon personality. Such a limited interpretation has evidently narrowed its usefulness, for it fails to acknowledge the genuinely natural function of anxiety.

In moderate quantities, anxiety is a very effective energizer and motivator. If it increases too much, however, it tends to destroy the capacity to reason efficiently and thereafter acts to inhibit flexible, creative thinking, replacing it with impulsive flight or fight behavior.

This is why excessive threat is a potent negative force in conflict management, and may limit one's capacity to use effectively the bargaining strategies available. The indiscriminate use of threat is dangerous at best. There are many forms of it, and no matter how eloquently it is expressed, one can never be sure just how much anxiety and impulsive behavior a given form will produce in an adversary.

The alternative to threat of any kind is that form of behavior which succeeds in reducing anxiety by providing evidence of positive concern for the survival of one's adversary.

Anxiety is a form of "noise" in human communication. In its loudest forms it will destroy listener and communicator effectiveness and impair social learning.

Since bargaining and trading depend upon good feedback they will be affected adversely by the loss of it caused by defenses against anxiety. This, of course, eventually will leave only blind conflict and further dueling as an alternative form of exchange.

A second qualitative difference is a willingness to take risks with other people, a basic element in trust. Interpersonal risk (Lundstedt, 1966) is a formulation which argues that people will withhold or give away personal influence and control over one another (share and exchange resources) only after an initial assessment by them of the amount of personal risk involved in such a relationship. The concept of interpersonal risk may be applied to the group or organization undertaking change. When the capacity to take interpersonal risks is inhibited by too much anxiety, guidance of change is impaired if not circumvented.

A very good strategy seems to be positive face-to-face confrontation. Fruitful negotiation apparently is impossible among human beings by remote control. People require the constant reassurance of others' intentions by personal contact.

Another way is to establish a policy of improving trust by reducing threat and, subsequently, the inevitable human responses of anxiety, frustration, hostility, and defensive behaviors of flight or fight associated with threat and anxiety. A good treaty is one special form. Another is to examine freely and with candor mutual goals and all available paths to such goals. All parties require accurate information about areas of mutual gain and agreement, as well as areas of legitimate differences. Still another is deliberate disengagement from old patterns of language and thought. Language and other cultural patterns can be serious barriers to effective mutual problem solving, and to renewed learning.

The intellectual and material resources of any person, group, or organization are usually ranked in terms of their survival value. Accordingly, as one bargains with the most precious elements of any social system, the price of a trading exchange will naturally be higher than for less precious elements. A price may be too high to allow trading if the things to be exchanged are too precious. At such a point normal further trading may become a threat and a conflict. To press one's advantage may convert a free exchange into a "win-lose" situation. An adversary will, as we have seen, respond with defense or offense if his capacity to survive is threatened. Negotiation involving the core resources of a person, group, or organization is less likely to result in fruitful trading behavior because of its threatening nature.

Should the strategy of conflict management one adopts initially begin at the periphery of a group's valued resources? Knowledge of human behavior suggests it might best begin there. Where one stops in trading and negotiation is a prgamatic matter guided by one's awareness of natural human boundaries which eventually become known through a process of social learning. They have often been called "territorial imperatives" indicating that they are functional borders and frontiers which are there to assure individual and group survival.

We may close this discussion in a lighter vein with the following thought as Kenneth Boulding expressed it in his "Ballad of Ecological Awareness":

> One principle that is an ecological
>   upsetter
> Is that if anything is good, then more
>   of it is better
> And this misunderstanding sets us very,
>   very wrong
> For no relation in the world is linear
>   for very long.

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CLOSING REMARKS

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We have come to the close of the Pollution Control Technology Conference. You have heard the papers and the discussions. I will not go into a detailed summary and reiteration, but I would like to hit a few high spots in closing.

The Conference was off to a good start when Mr. Strasser gave us an explanation of Technology Assessment. It seems to be many things to many people. I believe Mr. Strasser considers Technology Assessment to be a systematic planning and forecasting process--one that delineates options and costs and that encompasses economic, environmental, and social considerations, both external and internal to the program or product in question. Bad as well as good effects are considered.

From some industrial sector representatives we heard that pollution control laws and their administration are unrealistic, with possible disastrous consequences for some industries. From other industrialists, it appeared that fruitful discussions with enforcement bodies are possible - and that give-and-take can resolve many knotty problems.

We also heard from EPA lawyer Johnson in the Enforcement Division, which grapples with the permit system, how progress in turning the work over to the States is being made. The complexities of implementing a complex law on a tight time table were evident.

Norman Ross gave us some frank views as to how the Administration's Domestic Council carries out its functions and relates to the agencies.

We had a marvelous review of the behind-the-scenes work of the House Public Works Committee through Counsel Gordon Wood. It was made clear that the organizational structure and division of duties have made it nearly impossible to consider the environment in an integrated fashion. Changes in the offing may improve this situation.

After these opening sessions, we went into pollution control technology as it relates to air, solid wastes, radiation, hazardous wastes, and water.

It is quite obvious that nearly anything we do toward environmental improvement affects something else. Cleaning the air may produce large amounts of solids that themselves create a disposal problem. The scrubbing water can be a water pollution problem. Getting the water cleaner and cleaner creates more sludge. Are we using too much water for our needs? With water sales an important source of revenue to cities, should the water be conserved if the supply is plentiful? In industry, attention is focused on the industrial process itself and on avoiding pollution where possible.

We do know a great deal about radiation and the handling of wastes, but serious gaps are evident. Nuclear energy development will require continuing attention to safety.

We find that we are in a very early stage of dealing with hazardous wastes. We even have trouble knowing just what is hazardous and how hazardous. Shall we treat them? store them? recover valuables? or what can we do? Here is a place to truly focus upon how hazardous wastes come into being in the first place.

Solid wastes are tough problems. Mr. Bucciarelli told of good progress in closing dumps and instituting better regulations and disposal methods. The quantities of solid wastes, already staggering, are increasing. Can the ocean be an ultimate sink? Will we run out of land in a suitable location for land disposal? There are hazards to deep well disposal. Dick Eldredge has found that it was easier to write regulations than to solve a client's problem in an economical manner.

At the banquet Joe Moore explained the work of the National Commission on Water Quality. When speaking of trends in the environmental area, Joe noted the tendency to hire lawyers instead of engineers. He believes this trend may be in the wrong direction.

The relations of land use and planning to water pollution came in for discussion, as did materials and natural resources. Dr. Clark and Ken Klitz put these more indirect factors affecting pollution into perspective. Energy is a key word today. Kurt Yeager brought out clearly the interrelationships of the environment and energy. He showed the early plans for dealing with the multiple problems in seeking self-sufficiency in energy.

In our wrap-up session on Friday, Dr. Lee described some progress in cross media effects and emphasized that in our control strategy, we must consider pollutants from our industrial processes. We need to do more to develop an index of pollution that relates to air, water, and land.

Dr. Plumlee indicated that data on health effects from environmental pollution are sparse. What is the danger of living downwind from the activated plant or an incinerator? How do we achieve protection? We were pleased to hear that health effects work in EPA is increasing.

Dr. Tihansky demonstrated the very large costs of controlling pollution. What are the cost-benefit trade-offs of these actions? National damages from pollution in terms of esthetics, agriculture, fisheries, health, plumbing, and navigation amount to billions of dollars.

Our final talk by Dr. Lundstedt stressed the importance of the effects of technology on people. Plant siting considerations are vital. What are the community stresses resulting from development? Can you reverse the aging of a community? What kind of guidance can be given for management change?

What is the net result of our Conference? I believe that we can all agree that it was very informative. Thanks to excellent speakers, the Conference was stimulating. All of us should have gained in breadth as well as depth in the several subjects discussed. I trust, too, that audience interactions in and out of the meeting were useful.

The results of the Conference should not stop at an interesting two-and-one-half days. The practice of technology assessment should spread back to our colleagues and organizations. Ways of thinking about environmental matters should be expanded as a result of the Conference, and Conference proceedings can extend this information to many who could not attend.

And now, with our deepest thanks to the planners, the speakers, and to you, the audience, we bring this Conference to a close.

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